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INDIA

PART III

ADVANCED ECONOMIC GEOGRAPHY OF INDIA AND PAKISTAN

BY

H. L. CHHIBBER,

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With Illustrations

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BANARAS.

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Dedicated

to

Two Vice-Chancellors

Dr. Amaranatha Jha,

formerly Vice-Chancellor, Banaras Hindu University

AND

Pandit Govind Malaviya,

Vice-Chancellor, Banaras Hindu University,

and Member Constituent Assembly.

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Advanced Economic Geography

of

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FOREWORD

By

DR. AMARANATHA JHA,

M. A., D. LITT., L. L. D., F. R. S. A.,

Chairman, Public Service Commission, U. P.,
formerly Vice-Chancellor, Benares Hindu University
and Allahabad University.

There is a well-known doggerel:

"The art of Biography,
Is different from Geography.
Geography is about maps,
But Biography is about chaps."

And the manner in which Geography was taught when I was at school suggested that apart from maps—rivers, hills, towns, provinces, and countries—there was nothing else that Geography concerned itself with. It was regarded as a very progressive step that Geikie's "Physical Geography" was recommended to some of the more advanced students. No wonder the subject was not looked upon as being one of importance or value, fit to rank with Mathematics or Science. Much has happened since then. Geography has emerged as a subject of great practical and cultural importance and is now one of the major sciences.

There are many branches of Geography, many of which are not even today studied at the Universities in this country. Some of them should no longer be

neglected, for example, Biogeography, and Human Geography. Military Geography is taught in the Service Academies. Commercial Geography, which is concerned with production, transport, and exchange of useful goods, is included in many of the courses for a commerce degree. But one may say that even today many significant aspects of the subject are neglected, either because of paucity of funds or because of lack of vision in educational administrators. The border-land of Geography touches physics, astronomy, geology, anthropology, and oceanography. No institution of advanced studies can afford any longer to neglect such an important branch of study.

A man of great learning—one of those whose profundity is not synonymous with obscurity—says of Geography that "it deals with the form and motion of the planet" for as a knowledge of these is necessary for fixing positions on the surface and explaining the incidence of solar radiation, more fully with the forms of the lithosphere or stony crust of the earth, the extent of the water envelope or hydrosphere, the movements of water and of the all surrounding atmosphere, the distribution of plants and animals and very fully that of the human races, and with all the interactions and relationships between these distributions.

Professor Chhibber has written what must be the most detailed and comprehensive survey of the Geography of India. In the first volume of his book he dealt with the physical factors and structure of the

country. The second volume concerns the Geomorphology of India. In the present volume he has studied the natural resources—livestock, fisheries, forest products, mineral, fuel and power resources. It is a book which should be in the hands of our public men and specially of those who are drawing up plans for economic development. Dr. Chhibber says: "With an average population of about 200 to the square mile it would be incorrect to describe India as an overpopulated country. The problem is really one of underproduction." There are other observations that deserve respectful consideration.

During my stay at the Benares Hindu University I had the pleasure of meeting many distinguished teachers, and it is my hope that they will continue to do work that will redound to the credit of that seat of learning.

Allahabad,
April 22, 1950.

AMARANATHA JHA

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PREFACE

The environment of the country representing physical factors and comprising physical divisions, land-forms, climate including annual and seasonal precipitation and climatic regions, weathering and denudation, geology etc., has been discussed in Part I of this work. A comprehensive account of soils, the problem of soil erosion and the value of fertilizers and manures has also been given in Part I as a great majority of the people still depend upon agriculture. Finally a chapter on the Structure of India has been added.

In Part II will be found a systematic study of the Geomorphology of India.

In the present part an account of the natural or basic resources comprising agriculture, livestock, fisheries, forest products, mineral, fuel and power resources of the country has been given. The treatment is of course occupational *i.e.*, according to the type of activity. The relation of occupation to the natural environment has been amply emphasized. It must be noted that the environment in India is so varied that it offers the choice of many occupations. India's position almost at the centre of the Eastern Hemisphere and at the head of the Indian Ocean has to be noted and with her vast resources she can look forward to her future. In the first Chapter a preliminary survey of the Economic Resources of India has been made. This will give a concept of India as an internal and world economic power.

In Chapters II and III Irrigation has been dealt with, but with the partition of the country, some of the best irrigation works have passed on to Pakistan. It was found that the statistics on irrigation in the different works of reference were found to vary and thus the author approached the Central Board of Irrigation and the table given on page 9 is the one supplied by that organisation, for which the author wishes to express his thanks. There is now an attempt to develop

the rivers of India on a multipurpose basis. The reader would be well advised to read Chapters II and III in reference to the last two chapters.

Agricultural experts of the country will have a busy time for some years to come. Although a great majority of India's population are still engaged in producing food, the country is faced with a deficit in her food resources and huge sums of money are being spent in importing food-stuffs. With an average population of about 200 to the square mile it would be incorrect to describe India as an over-populated country. The problem is really of underproduction.

The yield for practically every commodity happens to be the lowest as compared to that of other countries. Even the quality of its produce is not very high; and it is disposed of in foreign markets at low prices. The difficulty is that our soils as a result of centuries of cultivation have been impoverished. Fertilizers and manures are practically unknown, although attempts are now being made to manufacture them in the country. Even the cowdung is used as a domestic fuel. Improved varieties of seeds are being introduced. With augmented irrigation facilities and reclamation of Khadar, Terai, ravine and usar lands, India can strongly hope to grow enough food to meet the country's requirements by 1951. The Government of the United Provinces is reclaiming the Khadar and theTerai lands and bringing them under cultivation with the help of tractors. The Tarai area comprises vast grasslands; only the climate is unhealthy. But it is familiar that some of the much worse climates of the world have been made fit for human habitation. There is no reason why with proper organisation malaria should not be eradicated from the Terai lands. There is the question of our small uneconomic holdings. In advanced countries they are organising agriculture on a co-operative basis. In this connection the author would draw the attention of the interested reader to the *Conclusion* on pp. 97-99. For every agricultural commodity the expert opinion as to how to increase the yeield has been given.

The same story is to be repeated in our animal husbandry as stated on pages 100-101 of this work. The cattle like the cow and buffalo play a very important role in the life of the country. There are 205 million cattle in India which comprise about one-third of the world's total stock of cattle and two-thirds of the buffaloes. Much greater attention has to be paid to pedigree breeding. In order to supply sufficient milk to the population in the interest of national health, dairy industry in India has undoubtedly to be considerably extended.

The various types of fisheries of India are extensive, varied and rich, but to supplement the food resources of the country, they, along with the related industries, have to be properly developed and exploited.

In India practically all types of natural vegetation ranging from hot, wet equatorial forests to the Alpine vegetation is found, but unfortunately our forest resources became particularly depleted during the last War. It would be our attempt to bring about afforestation of all those regions, particularly of the hilly portions of the catchment of our large rivers. Not only would it increase our forest resources, but it would also check the menace of floods and soil erosion.

The utilisation of our forest products properly, *e.g.*, for the manufacture of paper will greatly tend to reduce the paper shortage in the country. For further details the author would again invite the attention of the interested reader to *Conclusion* on pages 162-163 of the treatise.

Generally, the mineral resources of India in such works are dismissed in a few pages. The present author with his initial geological training as well has attempted to deal with them at some proper length. The importance of mineral industry in provinding the basic raw materials has to be appreciated. The estimated reserves of our iron ore deposits in Bihar and Orissa have been recently placed at 8,000 million tons and no doubt the iron ore deposits of India are among the richest in the world, but the question of conservation of metallurgical coal has been referred to in its appropriate places.

Likewise our resources of manganese ore are second only to those of Russia. Exporting it in the raw condition only helps India to earn some foreign exchange, particularly dollars.

Mica is an important strategic mineral and during the last War it was the only mineral which was flown by air to the United States of America. India possesses large resources of quality mica in Bihar, Rajputana and South India. She possesses large reserves of bauxite approximately of the order of 250 million tons. Aluminium industry has been established at Anupnagar near Asansol and also at Alwaye in Travancore. There was a project to establish aluminium reduction works in the Central Provinces also, but perhaps the delay is due to the belated development of power there.

Having lost the deposits of rock salt in the Salt Range to Pakistan, India has to concentrate on the salt manufacture in the Sambhar region and on the sea brine. There is a lengthy sea board from which enough salt could be certainly manufactured to meet the requirements of the country.

Among the precious stones, the find of emerald deposits is only of recent years and the account given is based on the author's own work.

India is also the leading producer of titania, beryl and monazite. The quantity of available thorium from the monazite deposits is about 150,000 tons. This mineral is a source of atomic energy and has to be conserved as far as possible.

Cement industry, for which raw materials occur in abundance in the country, has a great future as the demand for this commodity remains considerably in excess of the supply.

Large and varied deposits of building stones occur in India.

As minerals play such an important role in national economy of a country a chapter on the 'Conservation of Mineral Resources and National Mineral Policy' has been added. No

doubt these minerals have to be conserved as far as possible and they have to be worked in such a manner that their maximum longevity is ensured. The author considers that in view of the importance of the subject, this chapter deserves careful thought.

In the next chapter on Fuel and Power Resources, an account of the various coal deposits of India has been given. In view of their limited extent, proper emphasis on their conservation has been laid. In view of our limited petroleum resources, the development of power alcohol industry on a large scale deserves serious consideration.

In the last two chapters an account of the Hydroelectric Resources of the country has been given. At present water power is only developed to an extent of half a million kilowatts, but various projects have been launched, and when completed, the power available will be to the extent of 14 million kilowatts.

It has been rightly emphasized that the development of water power is the first *sine qua non* for industrial progress. These multipurpose projects for the development of rivers will be very helpful in the improvement of agriculture and rural industries. They will also help in the decentralisation of industries. Rural electrification and electrification of our railways offer a considerable scope for the utilisation of hydroelectric power. These projects, when completed, will be linked together and will form a vast national grid for the country.

The book has been written after considerable travelling and personal investigation. There is hardly any part of India which the author has not visited. He has travelled from the eastern extremity of India in Assam or rather beyond to the West Coast of India. Likewise he has travelled from Kashmir to Cape Comorin. Consequently he was not only able to verify what was already on record, but he was able to collect considerable information himself. Several parts of the book have been written from personal observation. How-

ever, the author must have drawn freely on the previous literature and in a conspectus of this kind it is impossible to thank every one individually. The writer here takes the opportunity of thanking all those whose work he may have used in writing the present book.

It may also be added that the writing of the book has taken about a decade. The first draft was completed in the autumn of 1939, but the author kept on revising the manuscript and adding the material, wherever possible. The book, therefore, is the result of considerable thought, research and study. The discerning reader will appreciate the labour which has been spent in writing this work. The author does not think it too much to claim that the book is uptodate to the time of printing. The pre-war statistics had to be used in places as the conditions after the War have not yet settled and sometime is bound to elapse before they are settled. However, wherever the later statistics have been available, they have been incorporated. Such an account of the economic resources of the country is really very essential. It gives the present landmark which is an essential prelude to all further research for improvement and conservation.

The book will be useful not only to students of geography, geology, economics and commerce, but also to the general public in grasping and dealing with the main problems confronting the country. Chapters on Irrigation, Agriculture, Livestock and Multipurpose projects for the development of river basins will be of great intereast to the students of agriculture. It is indeed true that the study of its advanced economic geography renders to India an important and distinctive service. The student would gain familiarity with the various national problems.

The country cannot afford to waste her natural or basic resources, otherwise the standard of living, which is already low, will tend to deteriorate still further. A balanced view of both short and long range problems has to be taken in the matter.

A word has to be said about the partititon of the country.

Since the 15th August, 1949 she has been split into India and Pakistan. The latter includes Eastern Pakistan which comprises about two-thirds of the former province of Bengal along with the district of Sylhet. The Western Pakistan includes the West Punjab *i.e.*, about two-thirds of the former province of the Punjab, along with N. W. F. P., Sind and Baluchistan along with the states of Kalat and Bahawalpur.

In India considerable integration of the states has been done, which have mostly merged with the different provinces of India or have formed their own units like Saurashtra and Rajasthan.

A reference may be made to the spellings of names. After the 15th August, 1947, the Government of India and various Provincial Governments have revised the spellings of place names, etc. For instance, the Ganges is now spelt as the Ganga, the Jumna as the Yamuna, Cawnpore as Kanpur and Muttra as Mathura. Wherever the new spellings have been incorporated their old equivalents have also been given.

It has been a great pleasure to dedicate this work to two Vice-Chancellors for their eminent services to the cause of education. The first half of the book was completed during the tenure of Dr. Amaranatha Jha, M.A., D.LITT., LL.D., F.R.S.A., as Vice Chancellor of the Banaras Hindu University, who is at present Chairman of the Public Service Commission of the United Provinces. During about a year he was at Banaras he endeared himself to everybody. The latter part of the book has been printed during the Vice-Chancellorship of Pandit Govind Malaviya, M.A., LL.B., member of the Constituent Assembly of India. He is the illustrious son of Mahamana Pandit Madan Mohan Malaviya of the sacred and revered memory, and the founder of the Banaras Hindu University. His love for the advancement of the University indeed knows no bonnds.

The book has been illustrated with many photographs, maps, cartograms and bar graphs.

With regard to the printing of the book great care has been given to proof reading and it is hoped that many misprints will not be found in the book. The author would like to express his thanks to Pandit P.N. Bhargava, the proprietor of Messrs Bhargava Bhushan Press, Banaras for any interest he may have evinced in the printing of the book.

BANARAS HINDU UNIVERSITY. H. L. CHHIBBER
1st *November*, 1949

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CHAPTER I

POSITION AND EXTENT

India occupies an almost central position in the Eastern Hemisphere. It has a length and breadth of about 2,000 miles in each direction. From south to north it extends from 8° North latitude to 37° North latitude. It extends from about 62° East longitude to 97° East longitude. In the north, the great Himalayas stretch from Kashmir to Assam. It forms a peninsula with a coastline of about 4,000 miles and has some great seaports.

It occupies an area of 1,631,501 square miles and represents the largest country in Asia and one of the largest in the World. It has a population of 388.8 millions, which forms nearly one-fifth of the total population of the world. In India, including the Native States, there are about 660 million acres of land, of which 40 per cent is cultivated. Of this, about 18 per cent. receives the benefit of irrigation.

A Preliminary Survey of India's Economic Resources

It may be stated at the outset that India is very rich in its raw materials. It is the premier producer in the world of many commodities. It has almost a monopoly of the world's jute production, her contri-

bution being 98.8 per cent. It is also a leading producer of rice (40 per cent.), groundnuts (37 per cent.) and tobacco (25 per cent.).

India possesses the finest deposits of mica in the world, a mineral indispensable to electrical and other industries. She holds the second rank in the world in regard of manganese ore. She is a formidable rival of Russia and at times actually holds the leading place and she beats Russia in the quality of her ore. India also possesses vast resources of rich iron ore. In 1941, India produced

1,896,000 tons of pig iron,
1,217,000 tons of ingot steel and
1,178,000 tons of finished steel.

Tata Iron and Steel Works have expanded and will have an ingot production capacity of 1,250,000 tons when the expansion is completed.

The total reserves of coal to a depth of 2,000 feet are estimated to be 60,000 million tons of which 20,000 million tons are workable, while 5,000 million tons are of good quality. One-third of this is caking coal suitable for metallurgical purposes, while the rest is non-caking coal. India will be faced with the necessity of importing coal in a few decades, unless that fuel is conserved.

She has also got very rich deposits of bauxite, the ore of aluminium. She leads the world in the production of ilmenite from which titania is extracted. With the development of the aluminium industry, this pro-

duction can be increased as bauxite deposits of India are rich in titania which would become further concentrated in the slurry mud. She is also the leading producer of beryl. The pre-war annual production of chromite amounted to 26,000 tons. The deposits of talc are one of the largest in the world. India contains the largest deposits of monazite containing thorium in the world. The latter can be used for developing atomic energy.

With regard to the manufacture of chemicals, Heavy Chemicals Ltd. now produce soda ash, caustic soda, sodium bicarbonate, bleaching powder, chlorine, bromide and various magnesium compounds, In Mysore, alcohol, acetone and calcium acetate are produced as by-products in the manufacture of iron and steel.

India is the world's largest sugar cane producer. There exist 175 large vacuum pan sugar factories and if restrictions had not been imposed, she would have been definitely in a position to export sugar. After the United States of America, she is the second largest grower of cotton. Textile industry of India is well established and is in a position to export some cloth and yarn.

India is also the sole producer of shellac and her annual production is 30,000 tons.

India has 205 million heads of cattle, which comprise about one-third of the total cattle population of the world. There are 93 millions of sheep and goats.

India has 43,000 miles of railway of which more than half is broad gauge. India has now 300,000 miles of roads of which 76,000 miles are macadam surfaced. She has some excellent trunk roads which connect its important cities. Indian National Airways and Tata's Airways are two concerns which operate air lines in the country. Her irrigation system is one of the best in the world.

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Showing areas irrigated by major and minor works, also by main and minor storage reservoirs and by tube wells. The areas served by important hydroelectric schemes, existing or projected, are also shown.

CHAPTER II

IRRIGATION

Irrigation is practised to prevent the failure of crops owing to uncertain, insufficient and irregular rainfall. For instance, rice and sugar cane require regular and sufficient supply of water and the deficiency of rainfall is made up with the help of irrigation.

The south-west monsoon brings rain to a very great part of India from June to October. Only the south-eastern coast of Madras receives rain from the north-east monsoon in winter. But some regions like the west coast of India, Assam and Bengal receive an excessive supply of moisture and floods are the result, especially in years of abnormal rainfall, while in some regions, e. g., N. W. F. P., the Punjab, Sind, the United Provinces, Bihar, the Central Provinces, Bombay and Madras the rainfall is inadequate for the proper growth of crops. In such regions the deficiency has to be made good by irrigation.

On pp. 141-1 2 of Part I of this treatise the important features of rainfall in India were noted which are recapitulated below:—

(1) Most of India's rainfall is from May-October and there is a prolonged dry season.

(2) The advent of the south-west monsoon may be delayed considerably, which will affect the *kharif* sowing.

(3) The south-west monsoon may commence much earlier, with the consequence that it may terminate much earlier. This will damage the *kharif* crops and also make the sowing of the winter or the *rabi* crops difficult or uncertain.

(4) Prolonged breaks of rain may occur during July and August when the standing crops need rain the most.

(5) The rain from the south-west monsoon generally falls in torrential downpours, with the result that a very great part of it is wasted as run-off without giving proportionate benefit to the soil.

For the reasons noted above cultivation of crops in India needs irrigation which has been practised from wells and inundation canals from the hoary past in India, but owing to vastness in size and variation in conditions, the system of irrigation, which is determined by physical features, viz., topography, geology, structure, etc. varies in different parts. For instance, in the Indo-Gangetic plains, canals can be easily dug in the soft alluvium and a perennial supply of water being available, there exists the finest canal system in the world, while in Peninsular India the country is uneven and rugged and there, except in the deltaic portions, tanks and storage reservoirs furnish the necessary irrigation.

At present there are about 79,000 miles of Government channels, which irrigate an area of 59 million acres out of a total of 308 million acres under cultivation and provide employment to 50 million people

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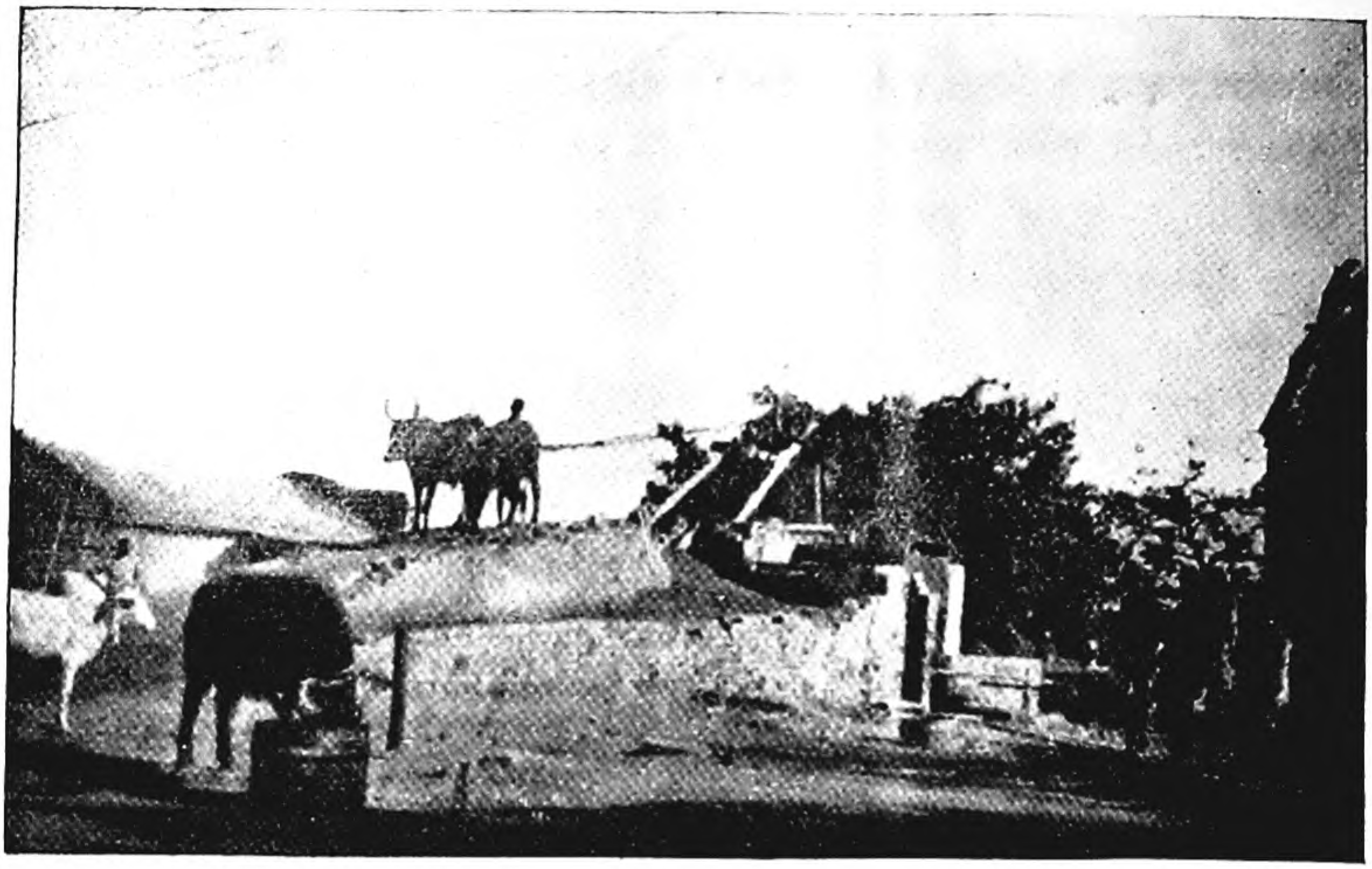

Fig. 1—Irrigation by *Charas*, i.e., by drawing water from a well in a large leather bucket by a pair of bullocks. This device is used on a large scale for irrigating crops where canal irrigation is not available. (*Photo: H. L. Chhibber.*)

Fig. 2—Agriculture in terraced fields in the Himalayas *en route* to Naini Tal from Kathgodam (See page 51). (*Photo: H. L. Chhibber*).

or more than one-seventh of the country's population. The total capital invested on these irrigation works has been about 150 crores of rupees and the value of crops raised annually is 114 crores which bring about a gross revenue of $14\frac{1}{2}$ crores, while the net revenue is $9\frac{1}{2}$ crores of rupees. The net annual return on these irrigation works is 6.09 per cent.

The following different systems of irrigation are practised in India:—

(1) *Canals*:—The Canals, which may be perennial or inundation, constitute the most effective form of irrigation. The former supply water throughout the year and are taken off from rivers by building weirs across them, e.g., the canals of the Punjab and the United Provinces, while the latter supply water during the rains only but provide water in autumn necessary for the sowing of winter crops. These canals irrigate 50 per cent. of the total irrigated area.

(2) *Wells*:—The water from the wells irrigates another 25 per cent. There are 3,000,000 wells in use in India which irrigate about 15,000,000 acres of land. Well water, which becomes available after great effort, is used for maturing high grade crops.

(3) *Tanks*:—Storage reservoirs, tanks, ponds, lakes, small streams, etc., irrigate the remaining 25 per cent. The exact number of these tanks cannot be known but in Madras alone there are about 70,000 tanks. Their size is variable. Some irrigate only about 50 acres, while others like the Periyar reservoir system irrigate 150,000 acres. The chief disadvantage with the tanks

is that they run dry during years of drought or insufficient rainfall.

(4) *Spray Irrigation*:—Recently spray irrigation has been introduced in some of the States in the U. S. A. and in Australia and this method is to be tried in India also. In this case, water is sprayed over the fields from canals and wells by water pumping machinery. This way the whole plant becomes wet, whereas the upper part is left dry, when other methods of irrigation are used. The Governments of the various provinces and the Indian States have been advised to try this method as an experiment. It has also been recommended to sell the water by volume. "Flood water farming" is also to be tried by spreading the flood water on the fields which will keep the soil moist during the period of drought.

Benefits of Irrigation:—Irrigation offers many benefits to agriculture. It makes multiple cropping possible and definitely increases the yield of crops, in some cases almost twice. It makes agriculture possible, where nothing would grow. It protects areas from famine and scarcity. It thus certainly adds to the prosperity of the cultivator and the country.

RETURN ON THE OUTLAY

Production and Protection Works

The Government have expended Rs. 154 crores in the construction of these canals which can be divided into two classes: (*a*) Productive and (*b*) Protective. The former class comprises those canals which yield 6 per cent. or more on the capital outlay, while the pro-

tective works do not produce the interest on the capital and are mainly intended to prevent the failure of crops. However, the net yearly income, after allowing all expenditure, is 5½ per cent. This, as remarked above, may be only four per cent. or less in some cases, as for example, the Agra Canal. But there are other instances, which yield a much higher percentage as shown below :—

The Godavari Delta in Madras	..	21 per cent.
Eastern Jumna Canal in the U.P.	..	32 ,,
Lower Chenab Canal in the Punjab	..	38 ,,

The following table gives the total acreage sown, the area irrigated by Government irrigation works and also the percentage of the irrigated area to the total area sown in the various provinces :—

Serial. No.	Name of Province	Area sown in (1940-41) Acres.	Area irrigated by Govt Works during 1943-44(Acres)	Percentage of irrigated area to the total area sown
1.	Baluchistan	*	25,156	
2.	Bihar	17,924,200	3,394,810	18.94
3.	Bombay	19,889,737	626,759	3.15
4.	C.P.&Berar	28,713,369	722,239	2.52
5.	Madras	31,979,126	7,852,684	24.56
6.	N. W. F. P.	2,356,662	524,918	22.27
7.	Orissa	6,100,661	828,277	13.58
8.	Punjab	28,170,480	12,483,235	44.31
9.	Sind	5,370,008	4,511,110	84.00
10.	U. P.	36,539,626	5,344,683	14.63
11.	Bengal	24,714,500	244,217†	0.99
12.	Assam	6,788,823	198,938	2·93
13.	Ajmer Merwara	403,405	11,684	2.87
14.	Rajputana	* *	* *	

* Latest figures available for 1938-39 is 478,700.

† Figure is only for area irrigated by Govt. Canals.

** Latest figures available for 1938-39 are 313,100 and 14,200.

It will be noted from the above table that the following provinces rank in order of their importance of the irrigated area:—

Punjab	..	about	12	million acres.
Madras	..	about	7.8	,, ,,
Sind	..	about	5	,, ,,
U. P.	..	nearly	5.3	,, ,,

But with regard to the percentage of the area irrigated to the total area sown Sind ranks first followed by the under-noted three provinces:—

Sind	..	84	per cent.
Punjab	..	44.3	,, ,,
Madras	..	24.56	,, ,,
N. W. F. P.	..	22.27	,, ,,

Important Canal Systems

The most important canal systems of India are noted in the following:—

The Punjab

1. The Western Jumna Canal
2. The Sirhind Canal
3. The Bari Doab Canals
4. The Chenab Canals
5. The Jhelum Canals
6. The Triple Canal Project
7. The Haveli Project
8. The Sutlej Valley Project.

To face page 10.

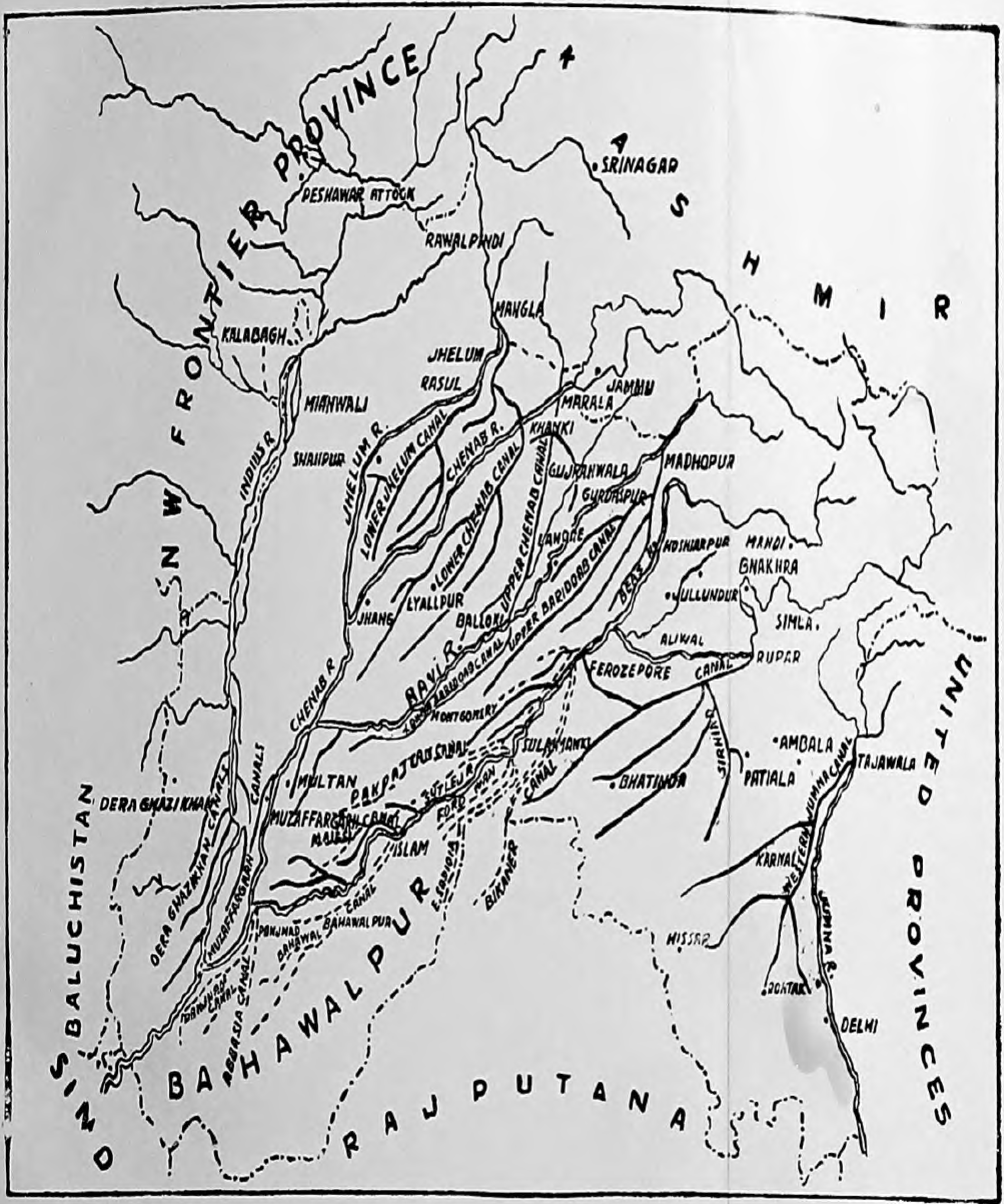

Fig. 1—Showing the Irrigation Canals of the Punjab.

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The United Provinces

The Upper Ganges and the Lower Ganges Canals
The Eastern Jumna Canal
The Sarda Canal.

Bihar

The Son Canal
The Tribeni Canal

Sind

The Sukkur Barrage Canals
The Desert Canal

Madras

Irrigation Canals of the deltas of the various rivers.

Irrigation in the Punjab

The Punjab is a land of the five rivers, viz., the Sutlej, Beas, Ravi, Chenab and the Jhelum. Besides, the Indus flows on the west and the Jumna on the south-east. All these rivers take their rise in the Himalayas and have plentiful and perennial resources of water, being fed by the snow during winter and both by snow and rains during summer.

The rainfall varies from 5 to 40 inches *per annum*. Towards the south, the States of Bahawalpur and Bikaner and the districts of Hissar, Karnal and Rohtak have a very poor rainfall but the districts fringing the hilly region have a good rainfall of about 40 inches and the annual average for the province is 28 inches. However, over a very great part of the province the rainfall does

not exceed 10 to 15 inches which is inadequate for the successful cultivation of crops. This deficiency in rainfall is compensated for by irrigation from canals for which the province is ideally suited on account of the flat nature of ground, the perennial flow of rivers and the soft character of its alluvium. In the early days an area of about 400,000 acres was irrigated, but at present the irrigation system of the Punjab is the most extensive in the World. Now, about 12;000,000 acres of land are irrigated by these canals and crops worth 39 crores of rupees are raised annually on the canal irrigated lands.

Canal Systems:—There are 13 canal systems already working in the Punjab, besides three inundation canal systems. Some more are either projected or are under consideration.

Western Jumna Canal:—This canal was originally constructed in the fourteenth century but had to be remodelled and improved considerably to make it a modern irrigation work. This canal has three branches, viz., the Delhi branch, which was reopened in 1819, while the Hansi branch was completed in 1825. The Sirsa branch was added in the last decade of the 19th century to irrigate land in the Karnal and Hissar districts comprising a somewhat precarious region. The present length of the main canal and its distributaries is about 2,000 miles which irrigate 800,000 acres of land *per annum*.

Sirhind Canal:—This canal, which was remodelled during 1870-80, takes off from the Sutlej at Ropar.

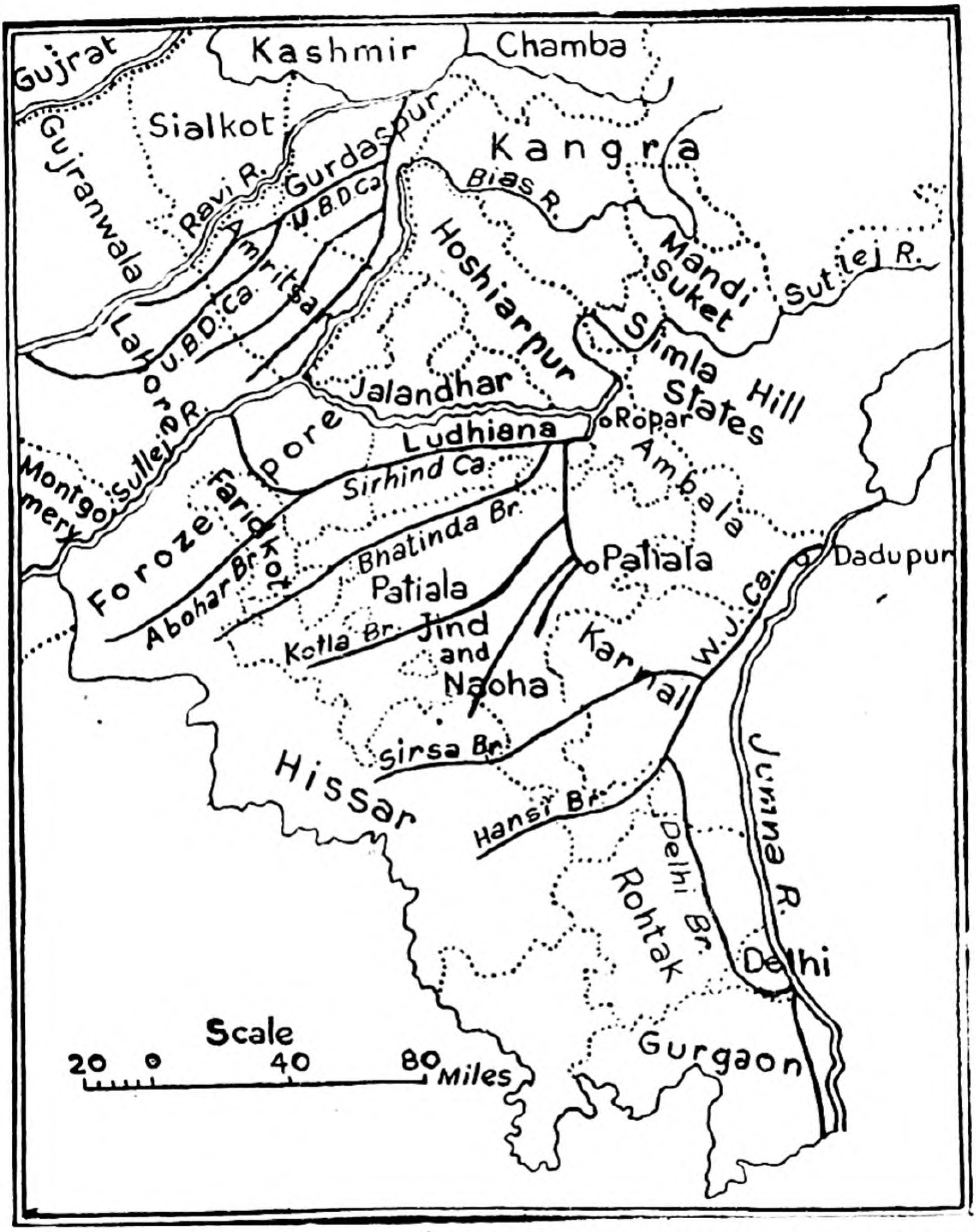

Fig. 2—Showing the Upper Bari Doab, Sirhind and Western Jumna Canals. These represent some of the older irrigation works.

Borrower's No.	Issue Date	Borrower's No.	Issue Date

Although actually opened in 1862 it suffered considerably from silt trouble. But the difficulties were gradually overcome and today this canal is said to be the most stable and least troublesome of any in the province. It irrigates the districts of Ludhiana, Ferozepore and Hissar in British India and the States of Patiala, Nabha, Jind, Malerkotla and Kalsia. The main canal and its distributaries have a total length of 3,733 miles which irrigate an area of 1.8 million acres. The return on the capital outlay is 11½ per cent.

Upper Bari Doab Canal:—This canal has been regarded as one of the classical irrigation works of Northern India. It is taken off from the Ravi river at Madhopur near Pathankot where it emerges from the hills and was intended to replace the old Hasli canal which provided irrigation to Lahore and Amritsar from the Ravi. Although the construction of the canal was commenced soon after the annexation of the Punjab but it was actually completed in 1859. The main canal and its distributaries comprise channels, 1,845 miles in lengh, which irrigate an area of 1¼ million acres *per annum*. This irrigation work has been responsible for converting wild jungle into one of the best agricultural lands in the province, comprising parts of the districts of Gurdaspur, Amritsar and Lahore.

Lower Chenab Canal:—It is taken off from the Chenab at Khanki, 8 miles below Wazirabad. This canal has been responsible for the colonisation of the area which it irrigates. It is one of the largest irrigation works and has channels, 2,437 miles in length which

irrigate more than $2\frac{1}{4}$ million acres. This colony with its headquarters at Lyallpur has proved to be the richest tract in the whole of the Punjab. Lyallpur is now a flourishing town which has a large export trade. The return on the invested capital is nearly 40 per cent. *per annum* and it is noteworthy that the annual value of the crops grown is about five times the original outlay on the canal. There has been a phenomenal increase in the population. In 1891, there were only 7 people to the square mile, whilst in 1931, the density of population had risen to 350 per square mile.

Lower Jhelum Canal :—It is taken off from the Jhelum river at Rasool, about 30 miles below the town of Jhelum. It irrigates an area of about 900,000 acres in the districts of Gujrat, Sargodha and Jhang.

Triple Canal Project :—The three canals, viz., the Upper Jhelum, the Upper Chenab and the Lower Bari Doab represent the Triple Canal Project, one of the most important irrigation works in the Punjab. It furnishes water for the irrigation of the waste lands of the Montgomery and Multan districts. There was no water available in the Ravi as a result of the Upper Bari Doab Canal. The Upper Jhelum Feeder Canal was taken from Mangla to take the surplus water to the Chenab at Khanki, the head of the Lower Chenab Canal. The Upper Chenab Feeder was taken off from the Chenab River at Merala. The water was poured into the Ravi at Balloki. The Lower Bari Doab canal was taken off from the Ravi here for irrigation of 4 million acres as noted above and the whole project was campleted at a

cost of Rs. $10\frac{1}{2}$ crores. It would be, therefore, noted that the Lower Bari Doab Canal, although taken out of the Ravi, depends upon the Chenab river for its water supply. This ingenious scheme has thus released the waters of the Sutlej for the Sutlej Valley Project, described below.

Sutlej Valley Project:—In this project is was designed to use the waters of the Beas and any surplus from the other rivers of the Punjab after meeting the needs of the other canals. This project comprises the four groups of canals, viz, (1) the Eastern, (2) the Dipalpur, (3) the Pakpattan and (4) the Mailsi canals. Three headworks or barrages have been constructed across the Sutlej river at Ferozepore, Sulemanke, Islam and one on the Panjnad river with 11 perennial and non-perennial canals with a total length of about 10,000 miles which irrigate over 5 million acres on both sides of the river and of this more than two milion acres comprise perennial, while the remaining represent non-perennial irrigation. It is noteworthy that this project has rendered the waste sandy lands of Bikaner and Bahawalpur States fertile and the extent of irrigation rendered possible in different regions is as follows:—

(i) British territory	: 1,942,000	acres
(ii) Bahawalpur State	: 2,825,000	„
(iii) Bikaner State	: 341,009	„

However, some of the land, particularly in the Bahawalpur State, has not been found suitable for cultivation and the amount of discharge in the Beas and the

Sutlej river in certain seasons is below normal. The results have been somewhat disappointing.

Haveli Project:—The Emerson Barrage, as it is also called, is situated two miles below the confluence of the rivers Chenab and the Jhelum and represents the largest work of its kind in the province. The project has been completed at a cost of 4 crores of rupees and will benefit parts of the Multan, Muzaffargarh and Jhang districts, which were being irrigated by the Sidhnai and the Chenab Inundation Canals.

A canal takes off from either end of the barrage. The Left Bank Canal will pour the Chenab and the Jhelum waters into the Ravi above Sidhnai whence three canals are taken off. This Left Bank Canal is 45 miles in length and has been rendered impervious with brick lining to avoid water-logging of the area which it traverses. The water, thus saved, will provide irrigation for an additional 50,000 acres which will produce an extra revenue of Rs. 200,000 *per annum*. If this experiment proves successful it will reclaim large water-logged areas for the production of the crops in the province.

The Right Bank Canal is $88\frac{1}{2}$ miles in length and will irrigate the riverine lands lying between the Thal and the Punjab.

These two canals will finally provide irrigation for 400,000 acres in the Jhang, Multan and Muzaffargarh districts. They will also provide regular irrigation to over 500,000 acres which received only precarious and irregular supplies before. Besides, it will irrigate

124,000 acres in the Montgomery–Pakpattan link and over 38,000 acres in the Burala Branch extension.

These canals will thus help to grow valuable crops over a million acres.

Thal Project:—The building of a weir or a barrage across the Indus at Kalabagh was commenced in 1939 but had to be abandoned in 1940 owing to the War. The canals will irrigate the sandy tract of Thal in the districts of Mianwali and Muzaffargarh, lying between the Indus and the Jhelum rivers. These canals will be only allowed the excess waters not required by the Llyod Barrage Scheme in Sind and the quantity of water allowed to the Punjab is 6,000 cusecs. The estimated acreage, which will be irrigated by the project, is 1,200,000.

Bhakra Dam:—The districts of Hissar, Rohtak, etc. constitute a very arid area in the Punjab, forming in reality the tail end of the Thar desert and the tract lies between the Sutlej and the Jumna rivers. There are two ways to irrigate this region, one by means of tube wells and the other by constructing a dam across one of the rivers and using those waters for purposes of irrigation.

The site of the Bhakra Dam and the contemplated vast reservoir lies in the State of Bilaspur. There were protracted negotiations between the Raja of Bilaspur and the Punjab Government about procuring the land. The project, which is estimated to cost Rs. 30 crores, one of the biggest ever undertaken in India, has been sanctioned by the Punjab Government. It will be one

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of the highest dams in the world ranking only next to the Boulder Dam of the Colorado.

Canal Colonies:—In the Punjab the problem was not only of irrigating land but of colonising some of the crown waste lands which helped to relieve pressure of population in some of the congested districts of the province. Before the construction of the canals, these waste lands were very sparsely populated by nomadic cattle owners and cattle thieves but the colonisation scheme has proved very successful and today there are nine canal colonies in the Punjab, out of which the following four are the most important :—

1. Lyallpur (Lower Chenab Canal) having an area of 4,000 square miles. It is the most important colony yielding the highest returns.

2. Montgomery (Lower Bari Doab Canal), 2,250 square miles in area.

3. Pakpattan (Nili Bar), 1,500 square miles in area.

4. Sargodha (Lower Jhelum Canal), 700 square miles in area.

These colonies, which were a portion of the desert before, now constitute important wheat granaries of India.

In conclusion it may be stated, as noted already, that the various irrigation works, described above, provide an annual irrigation to nearly 12 million acres of land which was almost a desert before their construction. Even now 5 million acres of desert land occur between the Jhelum and the Indus. In the South Eastern Punjab

there are large areas which stand in urgent need of irrigation. This will give an idea about the scope of extension of irrigation in the Punjab.

N. W. F. P.

The irrigation works in this province were undertaken actually to help the tribal people to settle down to peaceful pursuits like agriculture and it may be noted that the two canals, viz., the Lower and the Upper Swat canals, although there were difficulties in the beginning, have proved successful beyond expectations.

Lower Swat Canal:—This canal, as noted in the foregoing, was intended more to help the lawless tribes to settle down as peaceful cultivators on land and the project was sanctioned in 1876. This canal has proved a great success and now irrigates 160,000 acres of land which was absolutely an arid waste before.

Upper Swat Canal :—Encouraged by the success of the Lower Swat Canal, the construction of the Upper Swat Canal was undertaken which was completed in 1914. The head of the canal lies on the Swat river at Amandara, 3 miles below the fort of Chakdara. The canal traverses the Swat valley for four miles and it then passes through a tunnel, exceeding two miles in length to the Malakand hills. The canal bifurcates into two branches at Dargai. The main canal and the branches are 144 miles in length with 306 miles of distributaries. Besides the main tunnel, referred to above, there are seven smaller tunnels with a total length of one mile. The area irrigated comprises 200,000 acres.

Sind

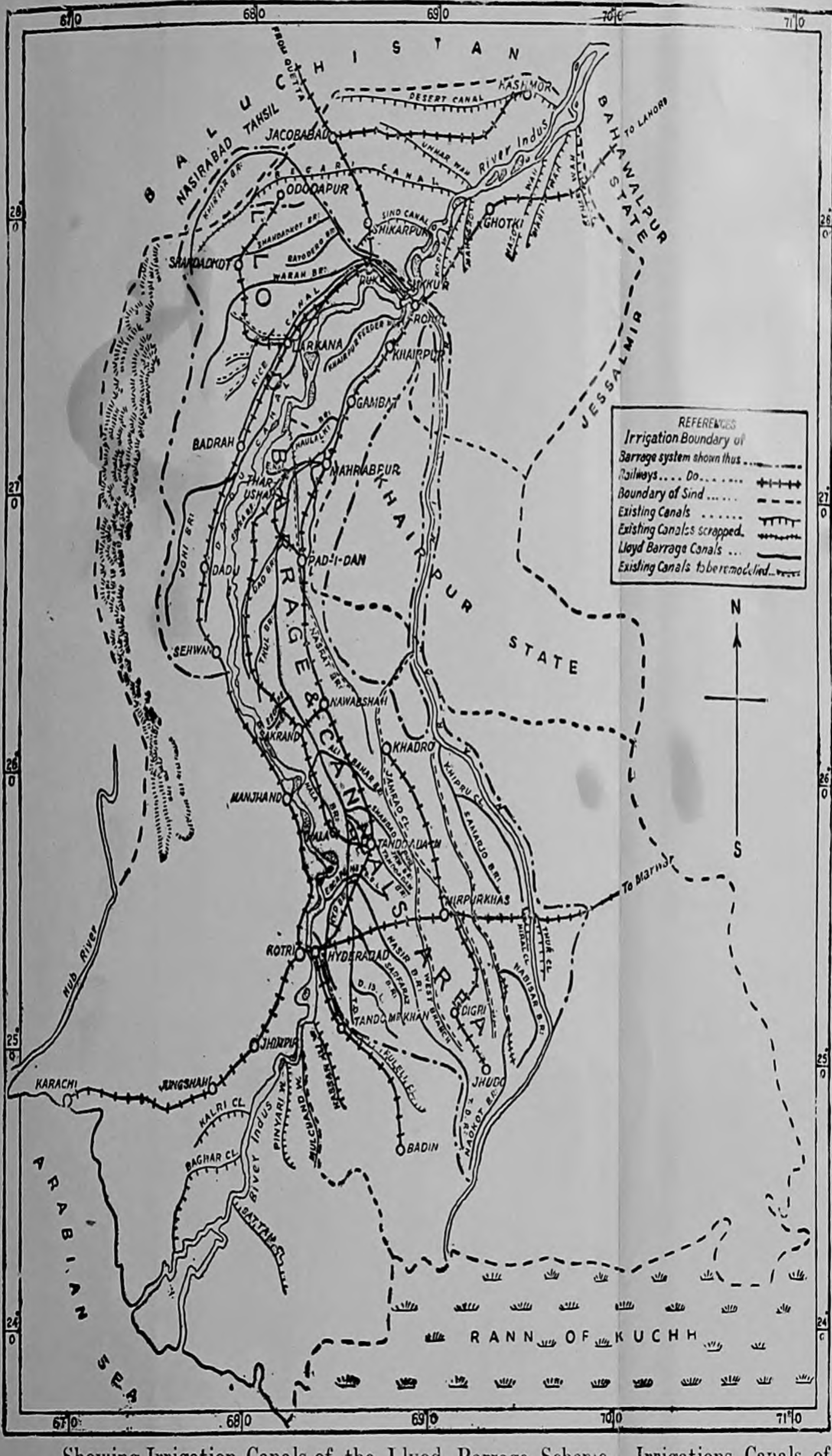
With respect to irrigation, Sind may conveniently be classified into three parts :—

(1) Llyod Barrage Scheme.
(2) Upper Sind.
(3) Lower Sind.

Llyod Barrage Scheme :—All the above works of irrigation are marvels of engineering science but the Llyod Barrage constructed across the Indus, three miles below the gorge at Sukkur, is the most imposing and represents one of the world's greatest irrigation schemes. It claims to be the longest barrage in the world. There were some inundation canals in Sind prior to the construction of the Barrage which irrigated 1,830,000 acres but the Barrage has provided irrigation to another 3,183,000 acres. A dam, 4,725 feet in length and consisting of 66 spans, each 60 feet in width and separated by piers, has been constructed across the Indus to control its waters which will be allowed to flow into seven canals with a total length of 6,816 miles which would irrigate 5,500,000 acres of desert land. Three canals have been taken off above the Barrage on the right bank, while four have been taken off from the left bank of the river.

The names of these canals along with their lengths are noted below (see Fig. 2) :—

Canals	*Length in miles*
Right Bank	
North-Western	36
Rice	82
Dadu	131



Showing Irrigation Canals of the Llyod Barrage Scheme. Irrigations Canals of Lower Sind are also shown.

Borrower's No.	Issue Date	Borrower's No.	Issue Date

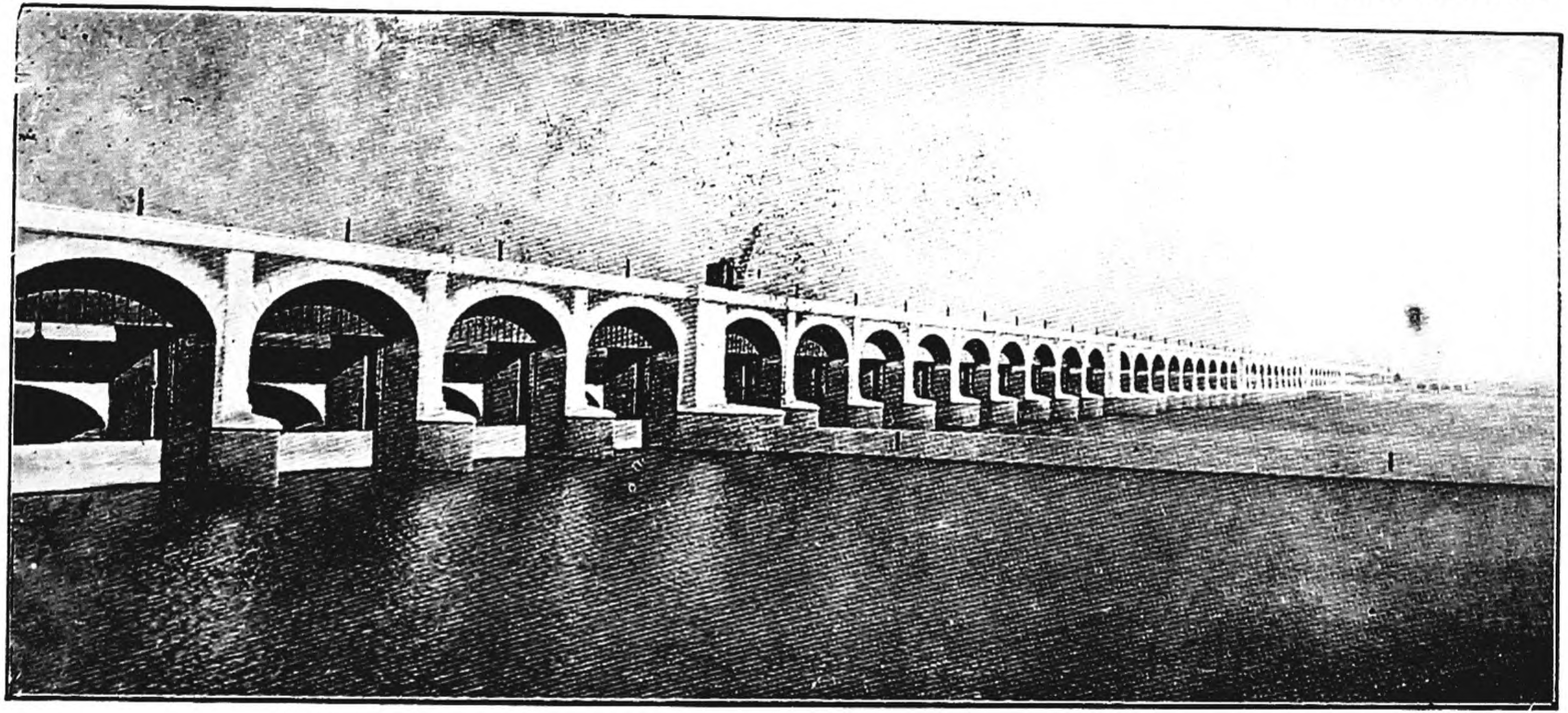
A general view of the Llyod Barrage and its seven canals.

Borrower's No.	Issue Date	Borrower's No.	Issue Date

Borrower's No.	Issue Date	Borrower's No.	Issue Date

PLATE V.

To face page 21.



Upstream view of the Llyod Barrage taken from the Left Bank Regulators.

Left Bank

Easrern Nara	... ...	226
Khairpur East	... ...	13
Rohri	... ...	208
Khairpur Feeder, West	... ...	45
	Total	741

The importance of these canals will be appreciated from the fact that the Rohri canal carries as much water as the river Thames in high flood. The total estimated cost of the whole scheme has been about Rs. 20/- crores. Irrigation from these canals commenced in June, 1932. This project is hoped to bring a new era of economic prosperity to the desert of Sind, which was lying practically waste before the construction of the Barrage. Large areas under improved varieties of cotton, wheat, rice, oilseeds and pulses have been brought under cultivation.For instance, the acreage under cotton, which was 300,000 acres with an average yield of about 100,000 bales, will now increase three or even four times. Again, area under wheat will increase from half a million acres to two million acres and will represent the most extensively cultivated crop under the Barrage Scheme.

The total length of these canals including the distributaries is 74,000 miles.

Upper Sind

It may be noted that Upper Sind will remain unaffected by the Llyod Barrage Scheme. There are three large canal systems in Upper Sind, viz., the Desert Canal, the Unharwah Canal and the Begari Canal, but it is proposed to remodel these at a total cost of about Rs.

64 lakhs, while the total cost of improving the existing inundation canals and the extension of irrigation facilities to new area is estimated at about Rs. 125 lakhs.

Lower Sind

Just as Upper Sind is located to the north of the extent of the Llyod Barrage Scheme, Lower Sind is situated to the south of it. It may be noted that with the construction of the Llyod Barrage canals, Lower Sind is likely to be affected adversely at the critical periods of the *kharif* season. The Government, therefore, gave assurance to the landowners that the irrigation canals of this region will be remodelled and improved. The canals of this area comprise the Fuleli and the Karachi canals. It may be noted that the Fuleli Canal System has been remodelled. Of the Karachi canals, the remodelling of the Kalri and Narichanch Canal Systems has been completed.

There are reports that the Sind Government propose undertaking the construction of two more barrages, but the details are not yet known. Of course, the proposal for a second barrage for Lower Sind, to be located at Kotri or Jherruck has been made but considering the small area and the unproductiveness of the country to be affected, the scheme was not considered feasible. However, it was reported recently that the Govenrment of Sind have placed orders for the machinery required for the costruction of a barrage in Lower Sind. The Lower Sind barrage, which is estimated to cost nearly Rs. 8 crores, will bring 2,600,000 acres of land under cultivation.

PLATE VI.

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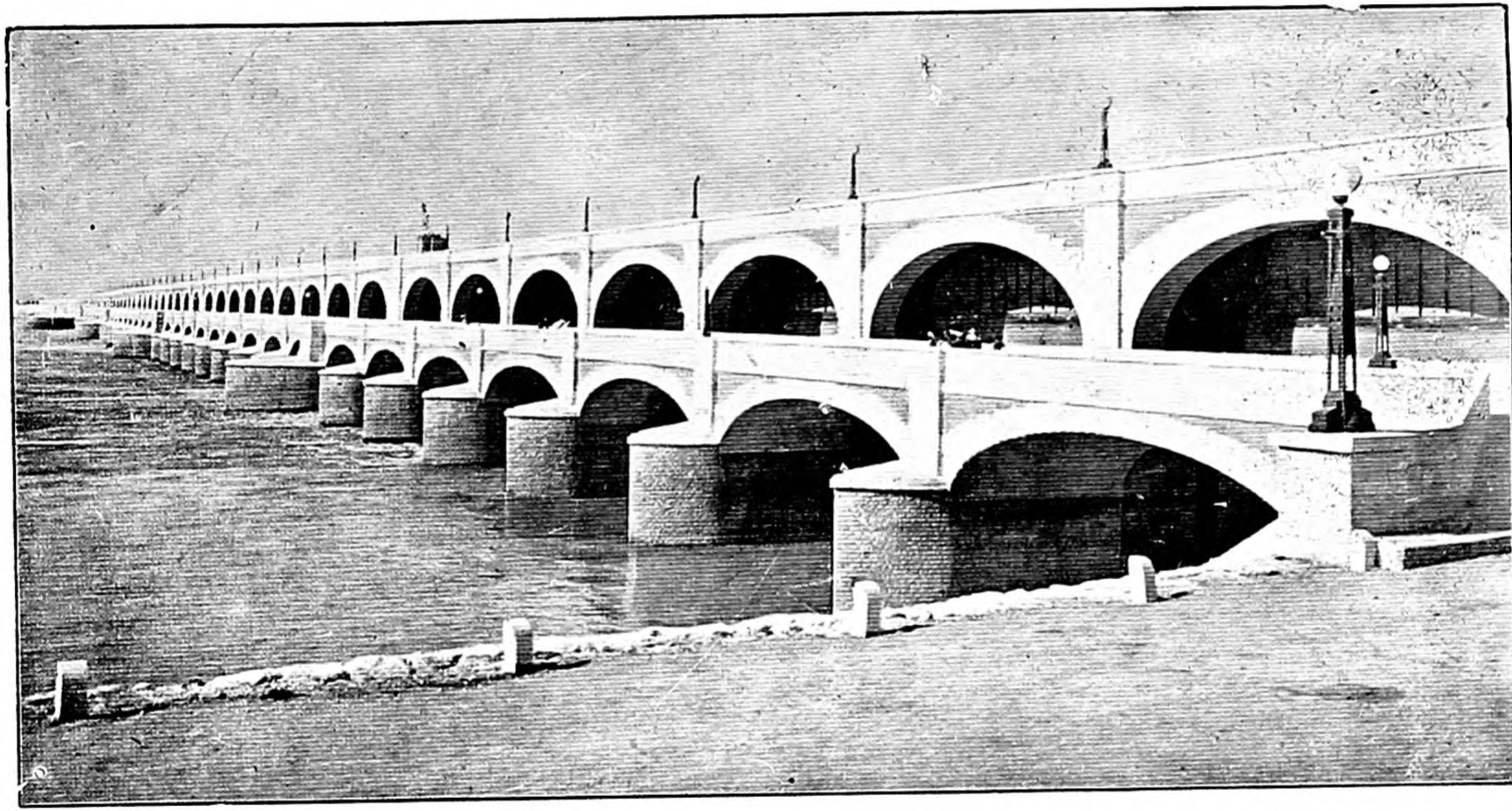

Downstream view of the Llyod Barrage showing the road bridge and the gate bridge.

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Baluchistan

The water resources of Baluchistan and Waziristan furnish a curious example of artesian water. The mountains of Baluchistan are fringed by alluvial fans or taluses, which are of Pleistocene age. Owing to very arid climate of the region such large angular deposits, which are locally known as *Daman*, are laid at the foot of the hills. There being no powerful drainage, these doposits become very large by gaining higher and higher ground on the slopes. The slope of these taluses is so gentle that they almost appear like very gently inclined plain. These compound taluses have a variable composition consisting of alternating coarse conglomerates and finer deposits, and the former being permeable, the scanty rainfall is absorbed and stored in them. These talus deposits thus perform a very important role in the economic geography of the region. Horizontal tunnels, which are locally called *Karez* and which may be several miles in length are bored into the sloping deposits until they reach the water level of permanent saturation. The water is held under hydrostatic pressure which makes it flow at the mouth of the tunnel or the well as it may be styled. Lately, artesian wells have been dug in these deposits which have been responsible for the development of some oasis in an otherwise barren desert.

CHAPTER III

Irrigation (Contd.)

UNITED PROVINCES

In parts of the Ganges–Jumna *doab*, the rainfall is about or below 30 inches *per annum* and this tract has been subjected to some of the worst famines. Consequently, after the famine of 1834, the construction of the Upper Ganges Canal, one of the greatest irrigation works in the world, was undertaken.

Upper Ganges Canal:—This canal is taken off from the Ganges near Hardwar, where the river just debouches from the mountains. Although its construction was commenced in 1842 but it was actually completed in 1854. It irrigates the northern portion of the Ganges–Jumna *doab*. The canal along with its distributaries is 3,888 miles in length and the area irrigated annually represents 1 million acres. With the help of the canal water, crops of the value of more than Rs. 3 crores are raised annually and in fact it has been responsible for converting a famine-stricken area into one of the richest tracts in India.

The main canal, which runs from Hardwar to Cawnpore, was constructed for navigation also, particularly for the transport of goods from Cawnpore to the sea until the quicker railway communication was established. To a certain extent it is still used for this purpose.

Lower Ganges Canal:—The rainfall, being heavy, a large number of tributaries have their source in the

terai and meet the Ganges in its middle course. Thus it was rendered possible to construct the Lower Ganges Canal. The construction of this canal was commenced in 1872 and its headworks are situated about 120 miles below that of the Upper Ganges Canal, with which it is connected. The main canal and its tributaries have a length of 3,827 miles and irrigate annually about a million acres of land.

The Jumna Canals :— There are two important canals of the Jumna, viz., the Western Jumna Canal and the Eastern Jumna Canal. The first has been described in Chapter II.

The original Eastern Jumna Canal had to be considerably realigned and remodelled and now from a common weir at Tajawala in the Saharanpur district this canal is taken off from opposite the Western Jumna Canal. The main canal and its distributaries cover a length of 900 miles and irrigate annually 400,000 acres of land. It is one of the most profitable irrigation works in the country.

Agra Canal :— This canal is taken out from the right bank of the Jumna at Okhla, about 11 miles below Delhi and is intended to irrigate an arid tract of land. The canal has 1,002 miles of channels which irrigate every year 280,000 acres of land.

Sarda Canal:— This project was designed to irrigate land in Rohilkhand and Oudh in the United Provinces, parts of which were liable to famine in years of scanty rainfall. This canal was opened in 1928 and the main canal and its distributaries in the original estimate pro-

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vided a length of 4,100 miles and 1,555 miles of drains. It represents the longest canal system in the world which irrigates :—

300,000 acres of wheat,
250,000 acres of sugar cane and
400,000 acres of other crops.

In 1941, another 352 miles of new channels were added thus supplementing 125,000 acres to the previously irrigated area. As a part of 'Grow More Food' campaign the Government have sanctioned another 800 miles of channels on this system. The new additions are expected to be completed by October, 1946.

Betwa Canal :—The Betwa river is a tributary of the Jumna. This canal was constructed as a protective work to irrigate a precarious area in the Jhansi, Jalaun and Hamirpur districts of the United Provinces. Two storage reservoirs have been built, one at the canal head at Parichha, 15 miles from Jhansi and the other upstream in 1906 and they store together 6,220 million cubic feet of water and irrigate in years of scarcity 200,000 acres of land.

Tube Wells

The ground or subsoil water is another source of water supply and irrigation, and in the alluvial area of the United Provinces the ground water level is fairly high. To tap this source, wells have been sunk from very ancient times for purposes of irrigation. Recently, the Government has constructed tube wells and each well is capable of irrigating roughly an area of one and a quar-

ter square miles. The tube well scheme was originally proposed in 1930 and a year later 9 tube wells were sunk, but by the end of 1945, 1,656 wells were expected to be completed. During the last three years three batches of 200 wells have been sanctioned by the Government and when this scheme is completed, 2,256 wells will be in operation, which will irrigate about 200,000 acres. It was forecast that the original project for 1,656 wells would produce a revenue of 49·3 lakhs in the year 1952-53, while the actual gross receipts for the current year are likely to be 52 lakhs. Thus the increase over the project forecast is 6 per cent.

The electricity required to pump water from these tube wells is provided by the Western Grid where hydro-electric power has been generated from the various falls on the Upper Canges Canal. Even land-owners are encouraged to sink tube wells and electricity is being provided at cheap rates for pumping water to provide irrigation for high class crops, e.g., wheat, sugar cane and cotton.

Besides these almost every village has one or more tanks from which irrigation can be practised but the difficulty with these tanks is that they are likely to run dry in case of failure of monsoons.

Bihar

Son Canals :—The Son canals derive their water from a weir built across the river Son near Dehri and this water is used in the irrigation of land in the Shahabad, Gaya and Patna districts. The anicut is one of the

longest in India and from this two canals, viz., the main Western and the main Eastern Canals, are taken. The former feeds the Arrah, the Buxar and the Chausa canals. The Arrah Canal is taken off at the fifth mile and runs parallel to the Son for 30 miles and turning northward and flowing past the town of Arrah it discharges its water into the Ganges. There is a fall of 180 feet and 13 locks have been constructed to allow for this fall.

The Buxar Canal issues forth from the Western Canal at its twelfth mile and meets the Ganges after a distance of 55 miles.

From the main Eastern Canal, the Patna Canal issues forth at the fourth mile and runs parallel to the Son until it meets the Ganges at Digha, a place between Dinapore and Bankipore. The total length of the canal is 79 miles and for the first 43 miles it flows through the district of Gaya and the remaining 36 miles are in the Patna district. The main canals are also navigable.

As a prelude to an extensive scheme for tube well irrigation, which is under consideration, the Government of Bihar have undertaken in the southern part of the Shahabad district, the boring of a dozen tube wells operated by electricity. Each tube well is estimated to irrigate about 500 to 1,000 acres of land with two to four miles of channels.

Bengal

In Bengal, where rainfall is generally adequate and where the problem is more of the drainage of surplus water, the Damodar Canal has been completed recently

which is intended to irrigate 200,000 acres of land in the districts of Burdwan and Hooghly.

Damodar Valley Dam Project: — Recently, the Damodar Valley Dam project has been proposed and at present the scheme, which is estimated to cost Rs. 55 crores and which will affect both Bengal and Bihar, is being examined with a view to commencing construction. The first dam will be at Tilaiya near Damodar, while the second dam will be across the river Barakar, which is a tributary of the Damodar river.

An attempt is being made to reconstruct the channels of Bengal rivers which are partly silting up. The reconstruction of these river channels and canals would mitigate the tremendous evil of monsoon floods over the adjoining lands. In fact, the same water could be utilised in irrigating the paddy lands.

Central Provinces

It was generally surmised that in this province there was fear of excessive rainfall rather than deficiency but the famines of 1899-1900 and 1902-03 proved otherwise. Only 7½ per cent. of crops were provided irrigation. This emphasized the necessity of irrigation and four major projects were taken in hand, viz., the Mahanadi, Wainganga, Tandula and Kharung canals. In addition a number of small storage reservoirs have been constructed to ensure cultivation in this region.

Mahanadi Canal :— This canal is designed to protect a large tract in the Raipur district. It has been visited by several famines, the worst being those of 1896-97 and 1899-1900 when crops of the value of 2½ and 3

crores of rupees respectively were lost. There was again almost another famine in 1902-03. It is a rice-growing area and the soil is very fertile. It was irrigation, which was required.

The headworks of this canal are located at Rudri, where a masonry weir has been built across the Mahanadi. In addition, a subsidiary reservoir at Maram-silli has been built on a tributary of the Mahanadi. The main canal and branches are 195 miles in length, and the distributaries, 741 miles in length. The cost of the project is about Rs. 1½ crores and the area irrigated covers 300,000 acres.

Wainganga Canal :— This canal irrigates parts of the Balaghat and Bhandara districts, which form a very precarious area. Besides the reservoir on the Wain-ganga, there is also the Sarathi reservoir. The main canal is 28 miles in length and a feeder channel from the Sarathi reservoir meets it at the 18th mile. The total length of the two branches is about 50 miles. The scheme will irrigate about 91,500 acres.

Tandula Canal :— This canal is a protective work for portions of the Raipur and Drug districts. The waters of the Tandula and Sukha rivers have been dam-med near their confluence by two separate earthen dams. The former is 1½ miles in length, while the latter is 1¼ miles long. The two reservoirs hold 9,000 million cubic feet of water available for purposes of irrigation.

Kharung Tank in the Bilaspur District :— It is a large storage reservoir on the Kharung river with 5,560 million cubic feet of water. Two canals, one on each side of the river, irrigate 95,000 acres of land.

In addition to the above works a number of small projects have been recommended in this province.

Bombay Presidency

Two great reservoir projects in the Bombay Presidency comprise :—

(1) The Pravara River Canals project.

(2) Nira Right Bank Canal project.

It may be noted that previous to the construction of the Pravara River Canals project, irrigation from the Godavari was carried out by the Ojhar Left Bank Canal. This canal issues out from the Pravara at Ojhar, about 40 miles north-west of Ahmednagar and a masonry weir, about 29 feet in height, was completed in 1873. A Right Bank Canal was taken off at the same point but it was left incomplete.

The new project includes a very large masonry dam, 270 feet in height at Bhandardara. The Pravara river flows here though a narrow gorge in the hard trap which furnishes an ideal site for the construction of a dam. It is noteworthy that it is the highest dam in India and perhaps the biggest in the world in respect of the depth of water stored. The lake is called the Arthur Hill Lake with a storage capacity of 10,800 million cubic feet of water which can be augmented to 12,900 million cubic feet. The catchment area, which is only 47 square miles, receives a torrential rainfall varying from 150 to 300 inches a year.

Besides the construction of the above dam, the weir at Ojhar has been raised in height and the Left

Bank Canal has been widened. The Right Bank Canal has been completed with a length of 33 miles and 56 miles of distributaries. The Left Bank main canal is 48 miles in length with 161 miles of branches and distributaries. The project irrigates 57,000 acres of a precarious area in the Ahmednagar district.

Nira Right Bank Canal :— This project comprises the remodelling and enlarging of the existing works which consist of a storage reservoir known as the Lake Whiting formed on the river Yelwandi, an affluent of the Nira. There is also a Left Bank Canal which is taken off from a pick-up weir on the main river Nira at Vir.

The Right Bank Canal is 109 miles in length, which will irrigate an area of 132,000 acres out of a total of 560,000 acres. The work is intended to protect a large portion in the Sholapur district which was frequented by famines.

Mutha Canal Project :— The object of this project was twofold. It was to protect a very precarious region in the district of Poona and also to assure potable supply of water for the town of Poona and the cantonments of Kirkee and Poona. Originally, a dam was built across the Mutha river which flows through the city, below the town of Poona. The water was thus contaminated with the sewerage of the town and ultimately a dam was built across the Mutha at Khadakwasla, 10 miles above Poona. Two canals were taken out and the Right Bank Canal brings water to Poona and irrigates the country lower down, while the Left

Bank channel, 18 miles in length, brings the supply of water to the cantonment of Kirkee. The project was commenced in 1864 which was completed in 10 years. The Right Bank Canal is 70 miles in length and irrigates a very precarious tract of land in the Poona district. Towards the end the Matoba tank receives the surplus water for further distribution.

Madras

In the Presidency of Madras, which ranks next to the Punjab in respect of acreage under irrigation, 10,655,537 acres are irrigated chiefly by the distribution of the delta waters of the Godavari, Kistna and the Cauvery (See Fig. 3).

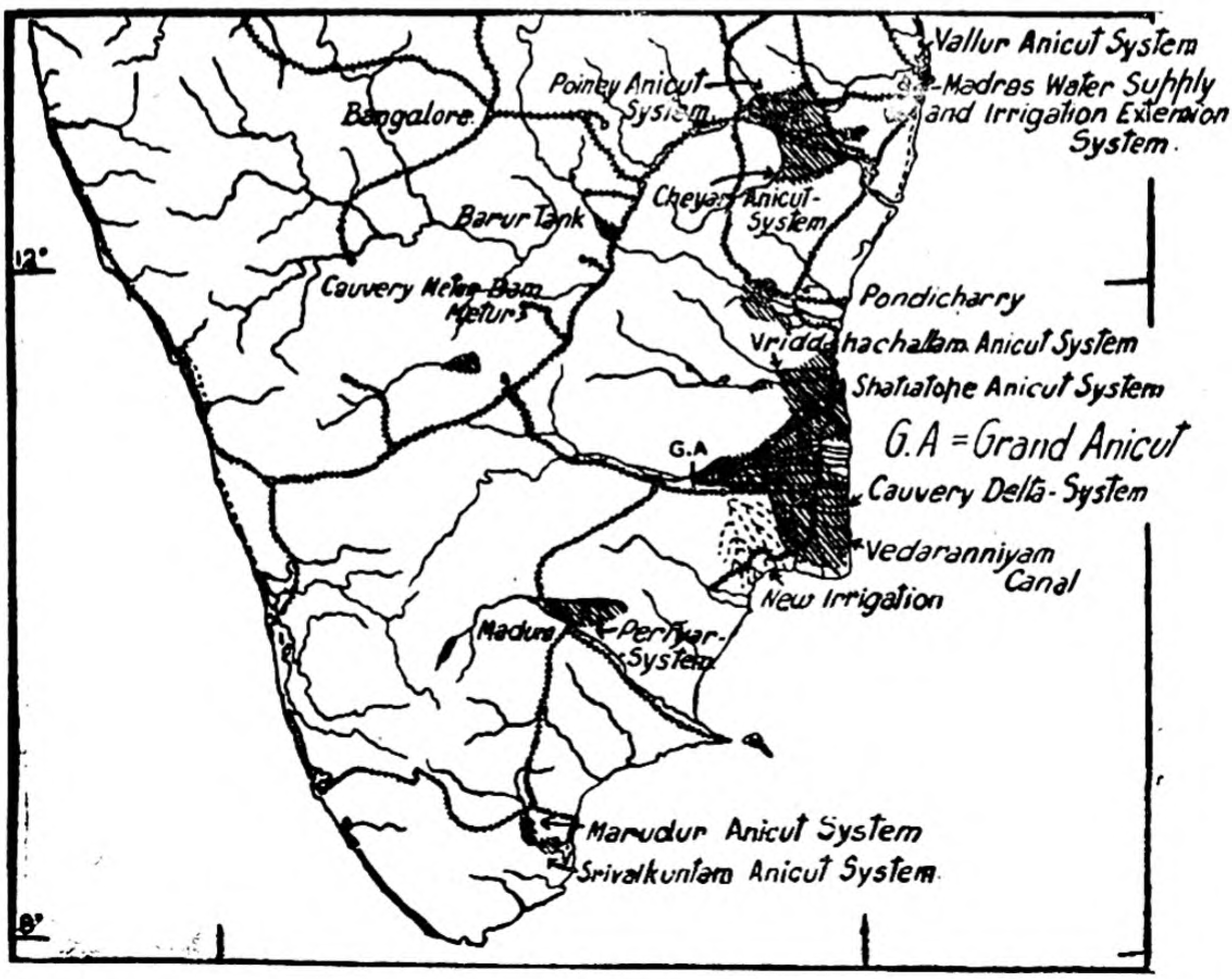

Fig. 3—Showing Irrigation Systems of the Southern portion of the Madras Presidency.

Irrigation in the Godavari Delta:— An account of the Godavari river is given on p. 40 of Part I of this work. It rises in the Western Ghats about 50 miles from the West Coast and drains its waters into the Bay of Bengal. Its catchment area comprises 115,000 square miles and the maximum discharge is 1½ million cubic feet per second. At the head of the delta it divides into the Gautami Godavari, representing the eastern branch, and the Vasishta Godavari. It is noteworthy that the original project was recommended as early as the end of the eighteenth century, but the famines of 1832-41 moved the Government to action and in 1844 Sir Arthur Cotton was asked to report on the project which, as originally executed, comprised the following :—

(1) The head regulator of the Eastern Delta System with a navigation lock and the connected under-sluices were constructed on the left flank of the river.

(2) Two weirs were constructed on the Gautami Godavari :—

(a) The Dowlaishwaram weir, 4,940 feet in length.

(b) The Ralli weir, 2,859 feet in length.

At the western end of the Ralli weir are the works of the Central Delta System. The Vasishta Godavari is also crossed by two weirs, viz., the Maddur and Vizeswaram weirs, 1,548 and 2,598 feet in length respectively. From the right bank of the latter extended the works of the Western Delta System.

It is noteworthy that the headworks comprised 2¼ miles of weir, 1½ miles of embankments, three canal heads with navigation locks and three sets of under-slui-

ces. The weir has since been raised and other structures improved.

Two canals, marking the exterior boundary of each section of the delta, have been taken out and with their branches they irrigate the intervening country. It may be noted that extensive drains have been provided to carry away any excessive water. Likewise, embankments have been raised on both sides of the river to prevent the flood water spreading over the arable land.

Thus the largest river of the Deccan has been harnessed to the benefit of man and the irrigation of the Godavari delta has proved of immense value to the country. It comprised a famine-stricken area which now forms extensive paddy lands.

The main canals also serve the purpose of navigation. The system represents 500 miles of main and branch canals with 2,000 miles of distributaries. It irrigates one million acres of land bringing in a return of about 26 per cent. on the capital outlay.

Irrigation in the Kistna Delta :— This area is liable to famine and a project for its irrigation was sanctioned in 1851. The Kistna rises in the Western Ghats and has a catchment area of 97,000 square miles. After a career of 800 miles it drains its waters into the Bay of Bengal. It has a maximum discharge of 1½ million cubic feet per second, which, however, decreases to only 100 cubic feet during the hot season.

About 60 miles from its mouth, near Bezwada, it passes between two hills of gneiss separated by a distance of 3,900 feet. This site has been chosen for the construction of the weir which was commenced in 1852. A main canal has been taken out on either side of the river with a network of distributaries extending over the whole delta. This system is connected by a high channel with the western high level canal of the Godavari System, thus completing the navigation between the Kistna and the Godavari deltas.

Irrigation by Pumping on Divi Island :— This island situated in the delta of the Kistna river has an area of 150 square miles or more than 100,000 acres. Its irrigation represents the first attempt in India to affect large scale irrigation by pumping. The soil is suited for paddy cultivation. Originally, attempts were made to provide irrigation by tanks and inundation canals but they were only partially successful. Now nine double-cylinder 160 H.P. Diesel engines have been installed for pumping. Each engine is capable of working a centrifugal pump which discharges 73 cubic feet of water per second on a 12–feet lift. The water is delivered into a canal system which comprises 26 miles of main channels and 130 miles of main and minor distributaries.

It would be feasible to have such projects in other parts of the country.

Irrigation in the Cauvery Delta :— The irrigation in the delta of the Cauvery river is of great antiquity, so much so that agriculture and irrigation have been

practically contemporaneous in the delta lands of Tanjore.

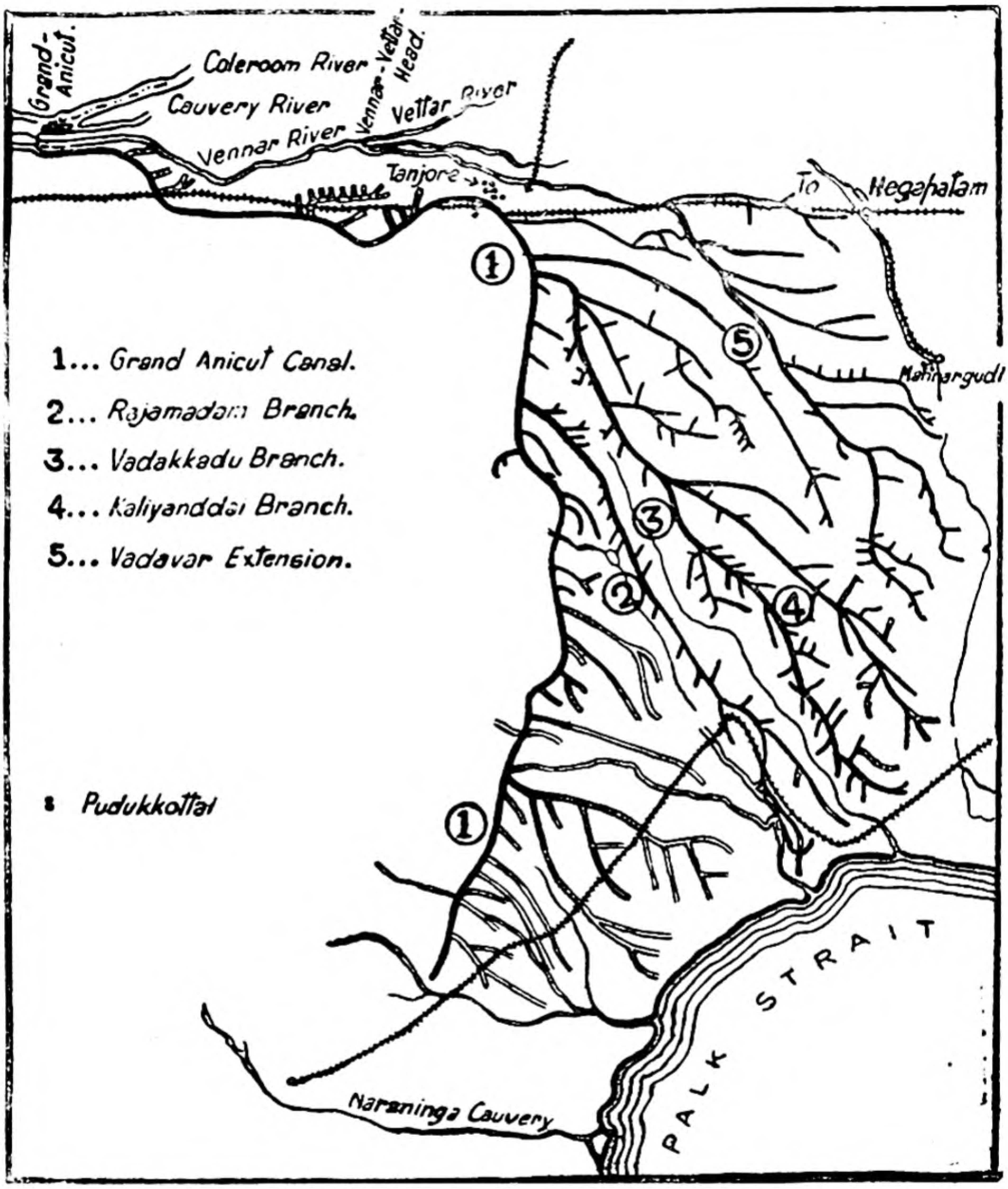

Fig. 4— Showing Irrigation Canals of the Cauvery Delta.

About 18 miles above the head of the delta, the Cauvery is divided into two channels by the narrow island of Srirangam with the result that the Cauvery proper flows on the right and the river Coleroon on

the left. The former divides and subdivides forming a network of distributaries of the delta.

Grand Anicut :— To prevent the waters of the Cauvery from being diverted into the Coleroon, a masonry weir known as Grand Anicut was constructed in the second century of the Christian era. It connected the left side of the Cauvery with the tail end of the Srirangam island. Its dimensions are as follows :—

Length	..	1,080 feet.
Breadth	..	40 to 60 feet.
Height	..	15 to 18 feet.

No sluices were provided in the weir but lengthy embankments, to protect the irrigated area from floods, were raised. But the Coleroon with the larger flood volume, steeper slope and shorter course diverted the waters of the Cauvery resulting in its deterioration and the development of shoals.

Upper Anicut :— Consequent upon this deterioration, the construction of a permanent masonry weir across the Coleroon at the head of the Srirangam island to distribute equitably the water in the two branches, was suggested. This Upper Anicut, which is a bar of masonry, 2,562 feet in length, was built in 1836. Twenty-two sluices were provided in the weir to permit the free passage of sand in order to prevent the silting of the bed of the Coleroon. But the sluices were absolutely inadequate and the bed was silted to the top of the Upper Anicut. During 1843-45 it was, therefore, found necessary to increase the sluice ways in the

Upper Anicut. However, during 1899-1902, the whole system of weirs had to be remodelled and the long lift shutters were provided both in the Upper and Grand Anicuts. The average area irrigated by the Cauvery prior to this reconstruction comprised 600,000 acres. It now irrigates over a million acres which brings in a return of 17 per cent. on the capital outlay. The main canals and branches are 1,500 miles in length, while the distributaries comprise another 2,000 miles. Thus the Tanjore district comprising the delta, owing to its fertility and irrigation has been styled "the garden of South India".

Cauvery-Mettur Dam :— A dam constructed at Mettur across the Cauvery impounds 93,500 million cubic feet of water and is believed to be the largest dam in the world. It irrigates an area of 1,300,000 acres in the delta of the Cauvery. This project also comprised an irrigation canal called the Anicut Grand Canal and also included the improvement and extension of the pre-existing Vadavar Canal.

The benefits accruing from this project comprise an increase of 300,000 acres of new irrigated land and the second crop cultivation will be augmented by 175,000 acres. Mettur now has become a great potential industrial centre having the advantages of cheap hydro-electric power, abundant water, and with proximity to great cotton and groundnut producing regions. With regard to communications, the area is well served by railway and the river Cauvery, and land for factory sites is also available.

Periyar Scheme :— The Periyar Scheme is one of India's most ingenious irrigation works and cost Rs. 108 lakhs. It irrigates 133,000 acres in the Madura district. By this scheme, a river, which should have flowed into the Arabian Sea, has been made to flow into the Bay of Bengal. A dam was built across a gorge in Travancore State, 3,000 feet above sea level, resulting in the formation of the lake Periyar with a gross capacity of 15,700 million cubic feet of water.

The waters of the lake are taken to the Madura plains through a tunnel 5,700 feet in length. It irrigates 12,700 acres in the Surulaiyar Valley and the waters are made to flow about 80 miles below the tunnel in the Periyar Main Canal, about 32 miles in length.

Tank Irrigation:— In this Presidency tank irrigation has been carried out from time immemorial and sometimes, it is stated, that there is more land under tanks than the land which is meant to be irrigated by them. But the supplies of water remained uncertain and careful attention has been given to their improvement. Existing tanks have been repaired and remodelled but many new works have been undertaken, which comprise the construction of weirs across several small rivers. This provides direct irrigation through canals taken from them but it also serves to replenish waters of small storage reservoirs. Taken together these small irrigation projects are of great importance and make a substantial contribution to the irrigated area of the province.

Mysore

Krishnaraja-Sagara Reservoir :— This storage reservoir will enable the generation of electric power up to

46,000 H. P. It will also help in the irrigation of 120,000 acres of drought land. The main canal is called the Irwin Canal. Out of this land, which has received irrigation, 18,000 acres have been brought under sugar cane cultivation, and a large sugar factory has been established at Mandya.

Other minor schemes, which will irrigate another 20,000 acres of land, have either been completed or are nearing completion.

Crops Irrigated

The crops, which are produced largely with the help of irrigation, are wheat and cotton in Sind and the Punjab and sugar cane and rice in other parts of India.

Problems connected with Irrigation

Waterlogging and Development of Saline or Alkaline Lands :— In the region irrigated by canals the water table rises in the contiguous fields and they are rendered saline or alkaline and ultimately become unproductive. Attempts are being made to mitigate this evil although the land thus involved is one-thousandth of the total irrigated area. Seepage from the canals can be considerably reduced by lining the canals with gypsum.

Sometimes, a special scheme is devised to drain off the surplus water from particularly swampy regions. An example of this method is furnished by the Deg Division where the partially stagnant water of an old blocked channel is carried off. This water is poured into the Uhl river of the Himalayas the waters of which are used to generate hydro-electric power.

Silt Problem :— Another problem is that of silt in suspension in the waters of the canals. This mud, if deposited in the canal beds, soon silts up the channel and the remodelling of the canal is expensive. It is intended that this silt should be deposited in the fields instead.

Fall of Water Table:— In the regions, where the water of the rivers is led away into irrigation channels, level of the water table falls, e.g., the Jullundur *doab*. This affects the level of water in the wells. This evil can be mitigated at least partially by going deeper in those wells thus reaching the lower water level.

Conclusion

Owing to its orographical features, India receives a large amount of rainfall during the monsoon from June to October. Only a few parts, e.g., Northern Baluchistan, N. W. F. P., the Punjab and part of the Ganges valley, and in the south, the Carnatic Coast receive rainfall in winter. It has been estimated that 60 per cent. of the total rainfall is lost by evaporation and run-off. Of the remaining 40 per cent., only 6.8 per cent. is utilized in irrigation. This will show what a great percentage of our water is wasted which could be certainly conserved in various ways for purposes of irrigation, etc. It is generally considered that India with a population of 389 million people is over-populated, but the average density of population is only 200 people per square mile. Even a preliminary survey of the country shows that there are still large tracts of the country which receive no irrigation and if by careful planning

those regions can be developed, our resources of food-stuffs and other economic products can be materially increased, thus raising the standards of living. On p. 254 of Part I of this treatise, the author concluded: "More irrigation projects and abundant suitable fertilisers are the two panacea for the main agricultural ills of this country". The author is of opinion that with thought and care, even what is called the Great Indian Desert, comprising Rajputana, etc., can be reclaimed and made to yield considerably greater agricultural and other resources than at present.

Water is useful and too precious to be allowed to be wasted as run-off. There is still a tremendous scope for the extension of irrigation in this country from storage reservoirs.

CHAPTER IV

AGRICULTURE AND AGRICULTURAL COMMODITIES

As discussed in Chapter XI of Part I of this work, India enjoys a monsoon climate, although the actual amount of rainfall varies from place to place. The agriculture in India provides a typical instance of agriculture in a monsoon region.

India forms one of the oldest agricultural regions of the world. About three-fourths of the people depend upon agriculture. Most intensive methods of agricultural farming are carried on to sustain a dense rural and urban population. There are generally small holdings, and hand tillage, using mostly simple implements, is carried on. These are some of the causes of India's rural poverty. Although an all round progress is observed in mining, industry and commerce, but an equal progress has not been achieved in agricultural farming in India. The plough is drawn by the bullocks or water buffaloes but most of the work is done by hoe, spade, sickle, etc. Perhaps cheap labour available in the country is responsible for not utilising labour saving devices.

In India agriculture is mostly a subsistence farming as the cereal produce is needed to feed the large population of the country. Cotton, jute, sugar cane, etc. are some of the main cash crops. Some commercial agri-

culture is also carried on, e.g., tea, rubber, jute, sugar cane, cotton and wheat. Less than an acre of land *per capita* is cultivated in India as compared to three of the United States of America, three-tenths of an acre in Japan, and one-half of an acre in China.

The farmer with centuries of practical experience is quite skilful. Multiple cropping in the form of two to three crops a year are raised on the same land. Interculture, i.e., growing of mixed crops is generally carried on. It increases the yield of crops and maintains the fertility of the soil.

'Fertilizers and Manures' used in Indian agriculture have been dealt with in Capter XIX of Part I of this work.

The cultivation of crops is generally governed by climate including temperature and rainfall conditions and thus certain crops are grown in particular seasons. In India there are two main crops:— (1) *kharif* and (2) *rabi*. The *kharif* crops are sown from June to August and comprise the cereals, pulses, oilseeds, fibres and other miscellaneous crops, while the *rabi* crops are sown from October to November. Besides, there are other crops which are grown at neither of the above seasons.

It may be noted that the following factors affect agriculture and the yield of crops:—

(1) Season. Rainfall affects the production considerably. In case of some crops, particularly cotton, frost may damage the crops.

(2) Manures and fertilizers.

(3) Improved varieties.

There is no control over (1), except by irrigation in case of deficient rainfall, but by manipulating (2) and (3), the outturn can be increased definitely.

The utilisation of land in India under agriculture, forests, etc., for the year 1937–38 is shown in the following table :—

(IN THOUSAND ACRES)

	British India	*Indian States*
Area by professional survey	511,794	147,822
Area under forests	68,001	19,123
Area not available for cultivation	92,402	27,759
Cultivable waste other than fallow	91,969	19,298
Fallow land	45,437	13,405
Net area sown	213,493	68,319
Irrigated area	52,833	10,765

It may be noted that out of about 282 millon acres sown, 249 million acres were devoted to the growing of food crops and pulses.

The area devoted to various food and other crops in British India and Indian States is tabulated below:-

Food Crops

(IN THOUSAND ACRES)

Crop	*British India*	*Indian States*
Rice	69,455	4,042
Wheat	26,633	7,508
Barley	6,311	823

(IN THOUSAND ACRES)

	British India	Indian States
Jowar (Millets)	20,702	13,943
Bajra (Millets)	12,498	6,237
Ragi (Millets)	3,475	2,317
Maize	5,633	2,268
Gram	13,622	5,376
Other food grains & pulses	28,393	6,421
Total food grains	186,762	48,935
Sugar	3,859	324
Other food crops[1]	6,701	2,764
Total food crops	197,322	52,013

Oilseeds

(IN THOUSAND ACRES)

	British India	Indian States
Linseed	2,489	945
Sesamum	2,438	1,640
Rape & Mustard	3,001	369
Groundnut	6,408	1,952
Coconut	657	825
Castor	400	935
Other oilseeds	1,592	1,263
Total oilseeds	16,985	7,929

1—Includes condiments and spices, fruits, vegetables and miscellaneous food crops.

Non-food Crops

(IN THOUSAND ACRES)

	British India	Indian States
Cotton ...	15,359	7,477
Jute ...	2,847	...
Other fibres ...	738	196
Indigo ...	38	1
Opium ...	9	16
Coffee ...	98	111
Tea ...	739	85
Tobacco ...	1,138	192
Fodder crops ...	10,411	2,398
Other non-food crops ...	1,179	974
Total of Non-food crops	32,556	11,450

Rice

Rice constitutes the biggest and the most valuable crop of the world. In India also it occupies a likewise position.

This plant comprises a very large number of varieties which, however, can be subdivided into two main groups. One is sown broadcast and it ripens in less than three months, while the other is grown in nurseries and is then transplanted. The latter matures in four to five months. It grows well in low-lying, heavy clays or heaviest loams, practically undrained and retaining water in the fields.

In the case of broadcast rice, seeds are sown fairly thickly, about 80 lb. to the acre. In August or

September the rice ripens and the harvest is in the form of paddy and rice is obtained by pounding or milling. The yield is 800-1,000 lb. to an acre of unhusked rice of which about one-third is the husk.

The transplanted rice ripens in November and the outturn is 1,200-1,400 lb. to the acre and generally represents better quality of rice. Superior qualities of rice are grown with canal irrigation and Dehra Dun Basmati rice is one of the very well-known qualities in India.

Barring the people of the Punjab and North–West Frontier Province rice enters very largely into the diet of the rest of India. It is the staple food of the people of Bengal and Southern India.

Climatic Conditions :— It is essentially a monsoon climate plant which requires abundant water and high temperatures. It is grown where the rainfall ranges from at least 50 to 80 inches a year, and during the growing season, there should be a minimum rainfall of five inches per month, otherwise the deficiency has to be made up by irrigation.

Soils :— In the plains it is grown on flat alluvial lands which have to remain flooded for a certain period during its growth. The alluvial soils, with a high clay and silt content, especially the clayey or the loamy soils, are the best as they can retain moisture. The clay loamy soils help good development of root, and an impervious layer of clay, about two feet below the surface, prevents further downward soaking and draining of water. Deltaic areas, flood plains and coastal plains furnish such

soil conditions and, that is, why rice is grown so intensively in these regions. As noted above, the transplanted rice is first sown in nursery fields and then the young shoots are transplanted in flooded fields with embankments to retain water and the plant must remain under water until it has reached a good size when it ripens under the heat of the sun.

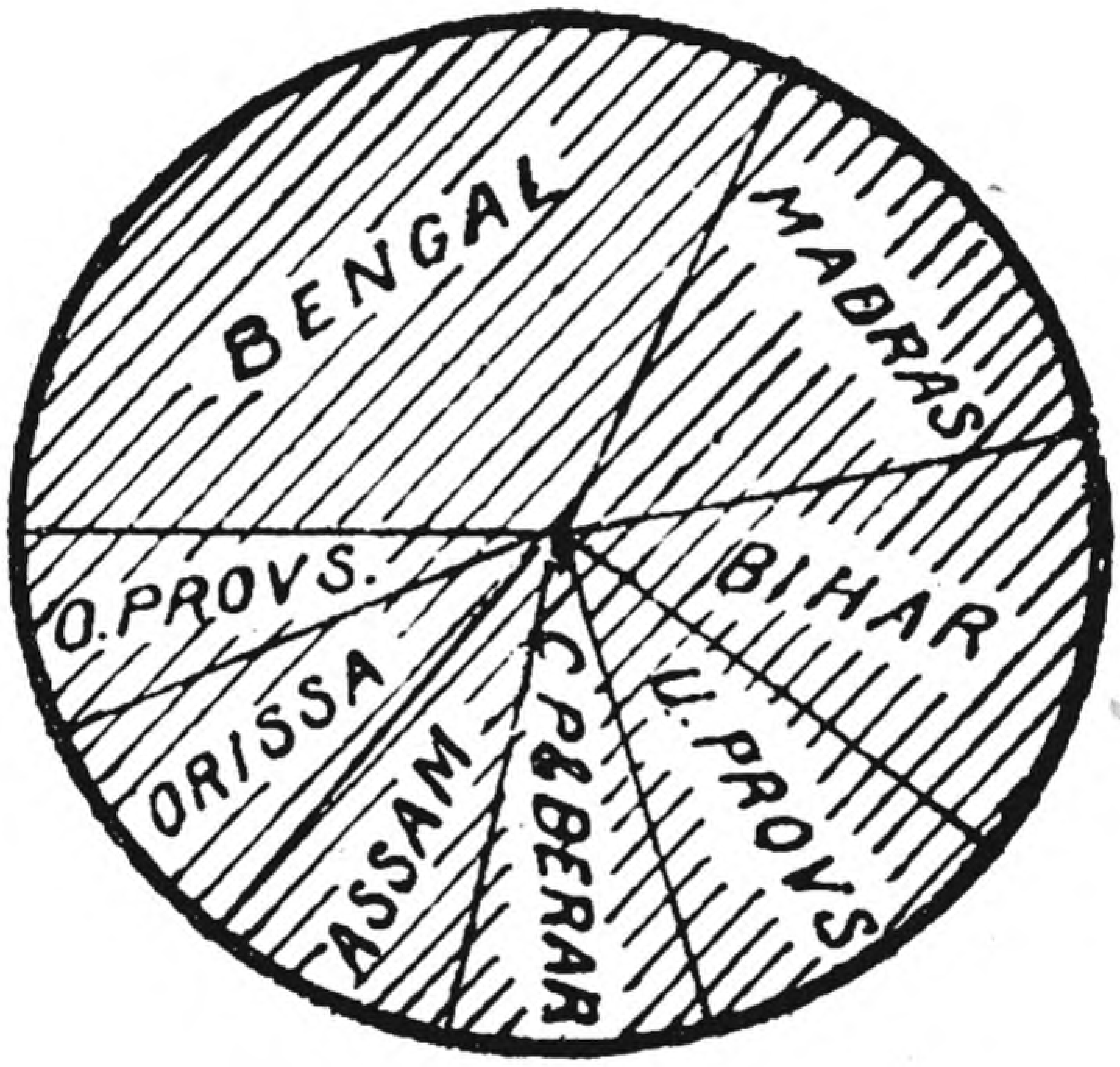

Fig. 5—Showing Provincial Acreage under Rice.

Regions where grown :—Rice occupies the largest area of about 75 million acres in India, occupying nearly one-fourth of the total cultivated area. The climate of India, especially that of the delta of the Ganges and the Brahmaputra along with the adjoining plains of the provinces of Bengal, Assam, Bihar, Orissa, eastern part of the United Provinces, the lower part of Sind, especially the deltaic portion of the Indus, the

narrow coastal plains of the Malabar and the Carnatic Coasts of India, is especially suited to its growth. Bengal together with Bihar, Orissa and Madras is responsible for 80 per cent. production of rice. In places, two to three crops of rice are raised annually.

Hill Cultivation :— Besides its cultivation in the plains or lowlands it is extensively cultivated in the hills on the sides of the valleys. They are levelled down into a number of narrow flat steps or terraces which form fields and the region around Naini Tal provides a notable example of this type of cultivation.

Time of Cultivation :— The seed is actually sown with the advent of the monsoon and its period of growth, requiring great moisture, coincides with the period of the monsoon. In the irrigated regions it is possible to have as many as three crops a year.

Output:— India produces over 30 per cent. of the world's rice and the output for two years is given below :—

1937–38	..	26,800,000 tons
1938–39	..	23,600,000 ,,

But unfortunatly her average output per acre is very small, about 1,100 lb. of paddy. Even Java and Siam obtain 50 per cent. more per acre. Below the yield of rice per acre of important rice-growing countries of the world is given :–

Spain	...	5, 000 lb.
Italy	...	3, 500 ,,
Japan	...	3, 000 ,,

For Korea and Japan, the yield per acre may be as much as 4,000 to 5,000 lb.

The primitive methods of cultivation in small holdings and lack of fertilizers and manures are somewhat responsible for this low yield and the use of machinery is almost unkown. The better varieties are sown with hand, as described above, and this increases very greatly the cost of production, while the inferior varieties are sown broadcast. Only six per cent. of land under rice is under improved varieties. Many rice research stations have been established and early maturing varieties are to be preferred. Organic manures, including green manures, are useful in increasing fertility of the soil. A leguminous crop before and after rice crop is very helpful in restoring the fertility of the soil. Oilcake fertilizers can also be used, but they prove relatively more expensive.

According to Dr. Burns[1] these yields can be increased by at least 30 per cent. Five per cent. can be augmented by using improved varieties, another 20 per cent. by increasing manures, while the remaining five per cent. can be added by preventing the ravages of pests and diseases. Another expert considers that there should be no difficulty in increasing the present average outturn by 50 per cent., i. e., 10 per cent. by sowing improved varieties and 40 per cent. by more manuring.

Husking of Rice :— Husk of the paddy has to be

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1. *Technical Possibilities of Agricultural Development in India*, Government Printing, Punjab.

removed to obtain rice. In rice-growing areas this is done on a small scale practically in every village by pounding it in a large wooden mortar with a pestle. But on a large scale it is done in rice mills, where two processes are followed. In one case the paddy is passed through rice hullers and the husk is subsequently separated. In the second case the rice is steamed and dried before passing through rice hullers.

Export :—The annual output of Indian rice was about 26 million tons in 1937-38 and the home consumption exceeds the total output. However, some is sold abroad and the required balance of 12-14 lac tons of rice is met by imports every year chiefly from Burma and Siam.

Wheat

In India wheat is an important winter or *rabi* crop which is sown about September to October and is harvested from March to May. Of côurse, in the south it harvests earlier. Wheat ranks next in importance to rice. The Punjab, Sind, North-West Frontier Province, the United Provinces, the western part of Bihar form a large wheat belt in North Western India with a tongue protruding into the Central Provinces. The Punjab and the United Provinces are alone responsible for two-thirds of the total acreage under wheat for the whole of India (See Fig. 6). There are small patches in other places where wheat is grown, e.g., around Jalna in Hyderabad-Deccan, in the eastern part of the Peninsula of Kathia-

war, etc. The crop has to be generally irrigated as the rainfall at that time of the year is not adequate.

Fig. 6—Showing Provincial Acreage under Wheat.

Total Acreage:— The total area under wheat is 34 million acres of which the Punjab's share is 10 million acres. In the Punjab half of the acreage is irrigated.

Soils:— Wheat grows well on clayey soils but heavy loams are also suited. The soil should be neither very stiff nor very soft.

Climate:— Wheat is essentially a winter (*rabi*) crop. It must have a cool and moist weather in the early stages, but at the time of harvest it must have a dry and warm weather. However, a shower or two at the end helps to swell the grain.

The portions of Northern India, mentioned above, enjoy suitable climate (temperature) for the growth of wheat. Rainfall is also adequate but, where insufficient,

the deficiency is made up by irrigation, and after preparing the land the seed is sown towards the close of the rains and the harvest is ready, as noted above. In Northern India there are winter rains which are favourable for the growth of wheat.

Yield:— The output of wheat per acre in India is still very low, although some European countries obtain three or even four times this yield as noted in the following table[1].

AVERAGE YIELD OF WHEAT PER ACRE

			Bushels
Holland	...	...	45
Denmark	...	...	43
Belgium	...	...	40
United Kingdom	...	...	33·5
Germany	...	...	32
New Zealand	...	...	30
Japan	...	...	28
France	...	...	24
Italy	...	...	21
Hungary	...	...	21
Canada	...	...	19
Bulgaria	...	...	17
U. S. A.	...	...	15
Argentine	...	...	13
Rumania	...	...	13
Russia	...	...	11
Australia	...	...	11
India	...	...	10

1. *The International Year-book of Agricultural Statistics,* International Agricultural Institute, Rome.

This small yield is due to the simple methods of cultivation, poor nourishment of the soil and the cultivation of low-yielding varieties. In the Punjab, the yield from the irrigated regions of the canal colonies is 16 maunds per acre, while the general average for the province is 10-11 maunds. The Department of Agriculture along with the provincial departments are now engaged in trying to grow new varieties which yield better outturns and which are immune from rust, etc. There is already more than five million acres of land under improved varieties and about half of this acreage is shared by the Punjab. According to Dr. Burns[1] if only improved varieties are grown, proper manures applied and disease eradicated, an average yield of 1,200 lb. per acre for irrigated land and 600 lb. for *barani* land is possible.

The World's output of wheat is 120 million tons or 4,450,000,000 bushels. India's output is about 11 million tons. India is fourth among the wheat-producing countries of the world, the first three being Russia, the United States of America and Canada. In case of failure of the Canadian crop, her position becomes third.

Exports :– India, having an immense population to support, can only export wheat in years of surplus harvests. In 1934–35, wheat exports were worth 10.5 crores of rupees.

Barley

The requirements of barley are practically the same as those of wheat. India is an important barley-produc-

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1. *Op. cit. p. v.*

ing country in the world and it is chiefly grown in the United Provinces, Bihar and the Punjab. It may require only smaller quantities of water. Wheat is, therefore, cultivated in irrigated areas, while barley can thrive even where much irrigation is not possible. It is grown both as human food and also as fodder for animals. The total area under barley is about 7.5 million acres.

The average annual production for the last 26 years is 2.6 million tons. Barley has been exported to the United Kingdom for making malt but the exports have declined. It is needed for feeding the poor population of India. The production of barley has also decreased as some of its acreage has passed under wheat, especially owing to irrigation facilities being available.

Maize

Maize is alleged to be a crop, which is primarily a denizen of the New World. In India it is a *kharif* crop which requires a long summer with adequate rainfall or irrigation when there is a break in the rains and a soil which can retain moisture. Waterlogging must be avoided. It ripens in a very short time and is, therefore, of special value as a food crop. It requires about 12 lb. of seed to the acre and yields 1,000-1,500 lb. per acre or even more. However, the average yield has been estimated at 800 lb. per acre which by better farming can be increased to 1,000 lb. per acre. It is used both as human food and also, particularly the leaves and the stalk, as a fodder for cattle and pigs. The area, where it is chiefly grown, includes the United Provinces, Bihar, the Punjab and the North-West Frontier Province.

The total acreage under maize is given already and the total annual production is 2.12 million tons. The production of the three leading provinces is shown below :—

United Provinces	836,000 tons
Bihar	441,000 „
Punjab	405,000 „

Millets

The millets comprise both tall and small varieties. The former comprise *jowar* and *bajra* which are 6-8 feet in height, while the latter comprise *mandua*, *kodon*, etc., which are two to three feet in height.

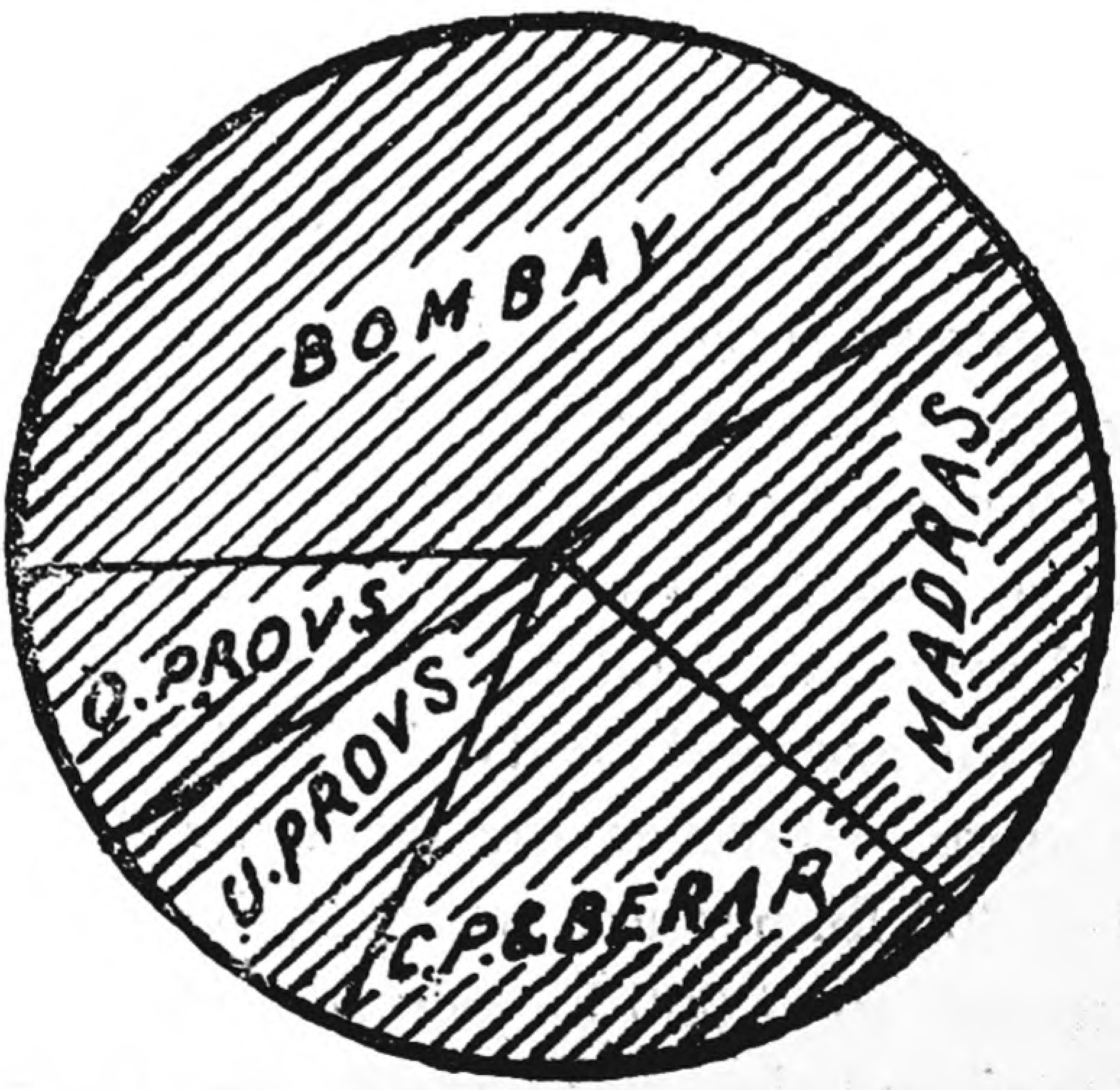


Fig. 7—Showing Provincial Acreage under Jowar.

Jowar :— Jowar is the commonest *kharif* crop, grown generally where rice is not the staple food. It is culti-

vated usually on loam or even clay. It does not require much irrigation and it is sown in July as soon as the earliest sowings of cotton, maize, etc. have been finished. Its growth is rapid and it ripens in November. Its yield for the irrigated area varies from 1,200 to 1,500 lb. to an acre, while the yield for the unirrigated land varies from 100-700 lb. per acre. It is stated that an increase of 20 per cent. is possible.

Bajra :— *Bajra* (*Pennisetum typhoideum*) is generally sown on poor sandy soil. It requires little manure and little irrigation. It ripens about the end of October, somewhat earlier than *jowar*. Its average yield for the last 12 years is 367 lb. per acre. According to Dr. Burns an increase of 25 per cent. is possible. It forms one of the chief foods of the poorer classes and is generally eaten in cold weather, being a more heating food.

Small Millets :— These represent *mandua*, *kodon*, *sawan*, *kakun*, the names varying from place to place. *Mandua* is a great staple in the hills.

Pulses

Pulses enter largely into the dietary of India and are an important source of proteins. There are many varieties of these, chief of them being peas, grams, beans, *mung*, *mash*, *arhar*, *masur*, etc. and they are grown everywhere in India. They also furnish useful leguminous rotations to increase fertility of the soil.

Gram :— It represents one of the commonest pulses of India. It is grown commonly in the Punjab, the

United Provinces, Bihar, the Central Provinces and Hyderabad-Deccan. It is used both for human consumption and also for feeding animals. Like wheat and barley it is cultivated as a *rabi* crop. It prefers a light soil, which is well drained. Consequently gram is cultivated on soils, which are too poor for wheat. The crop does not require any care after sowing and with irrigation the yield is definitely increased. Within recent years gram blight has reduced the acreage under it in the North Punjab. The production during the quinquennium ending with 1941-42 has fallen to 3 million tons which used to be four million tons during 1917-18 to 1922-23.

Peas :— Peas generally comprise two varieties : (a) the garden pea (*Pisum sativum*) and (b) the field pea (*Pisum arvense*). The latter is believed to be the old cultivated variety and is generally grown as a field crop in the United Provinces, Bihar, the Central Provinces, Bombay and the Punjab, while the former is believed to be of recent origin. It is grown as a *rabi* crop in Northern India on heavy soils, e. g., clay loam and loam.

Arhar and Tur :— This pulse, which is commonly cultivated in the United Provinces, Bihar, Bengal, Assam the Central Provinces, Bombay and Madras, is grown alone but more commonly as an interculture with *bajra*, *jowar*, cotton, etc. There are two varieties. The first is called *arhar* which is a late maturing variety and is generally grown in the United Provinces, Bihar, Bengal and Assam. The second variety, *Cajanus indicus* var. *flavus*, is an early maturing variety and is generally

cultivated in the Central Provinces, Central India and Bombay. With good soil and good spacing the plant may be 6 to 7 feet in height. The plant prefers a fairly moist climate during the early period and, that is why, it is grown as a *kharif* crop. It is unable to withstand frost, which determines its northern limit. It is grown on almost all varieties of alluvial soils and it is also grown on the Black Cotton soil. However, it prefers a light moist soil for the unrestricted growth of its roots.

Sugar Cane

Sugar cane is definitely a tropical and sub-tropical plant and it has been grown in India from very remote times. But the tariff protection afforded by the Sugar Industries Act of 1932 provided a great stimulus to the cultivation of sugar cane in India. It is an important sugar cane-growing country and has the largest acreage of all the sugar cane-growing countries of the world. Sugar cane is grown largely in the sub-montanne districts of Northern India, comprising particularly the *terai* area. A very conspicuous example of this is furnished by Gorakhpur and the adjoining districts, where extensive land has been brought under sugar cane which feeds so many large vacuum pan sugar factories located there. But it is also successfully grown in the Indo-Gangetic plains (See Fig. 9). About half the area under sugar cane lies in the United Provinces. Next comes the Punjab with an area of 12.1 per cent., while Bihar is close upon it with 10.1 per cent. of the total

area (See Figs. 8 and 9). More than 80 per cent. of the total area is under improved varieties, evolved especially at the Imperial Sugar Cane Breeding Station, Coimbatore. Here varieties have been evolved by crossing sugar cane with some species of bamboos.

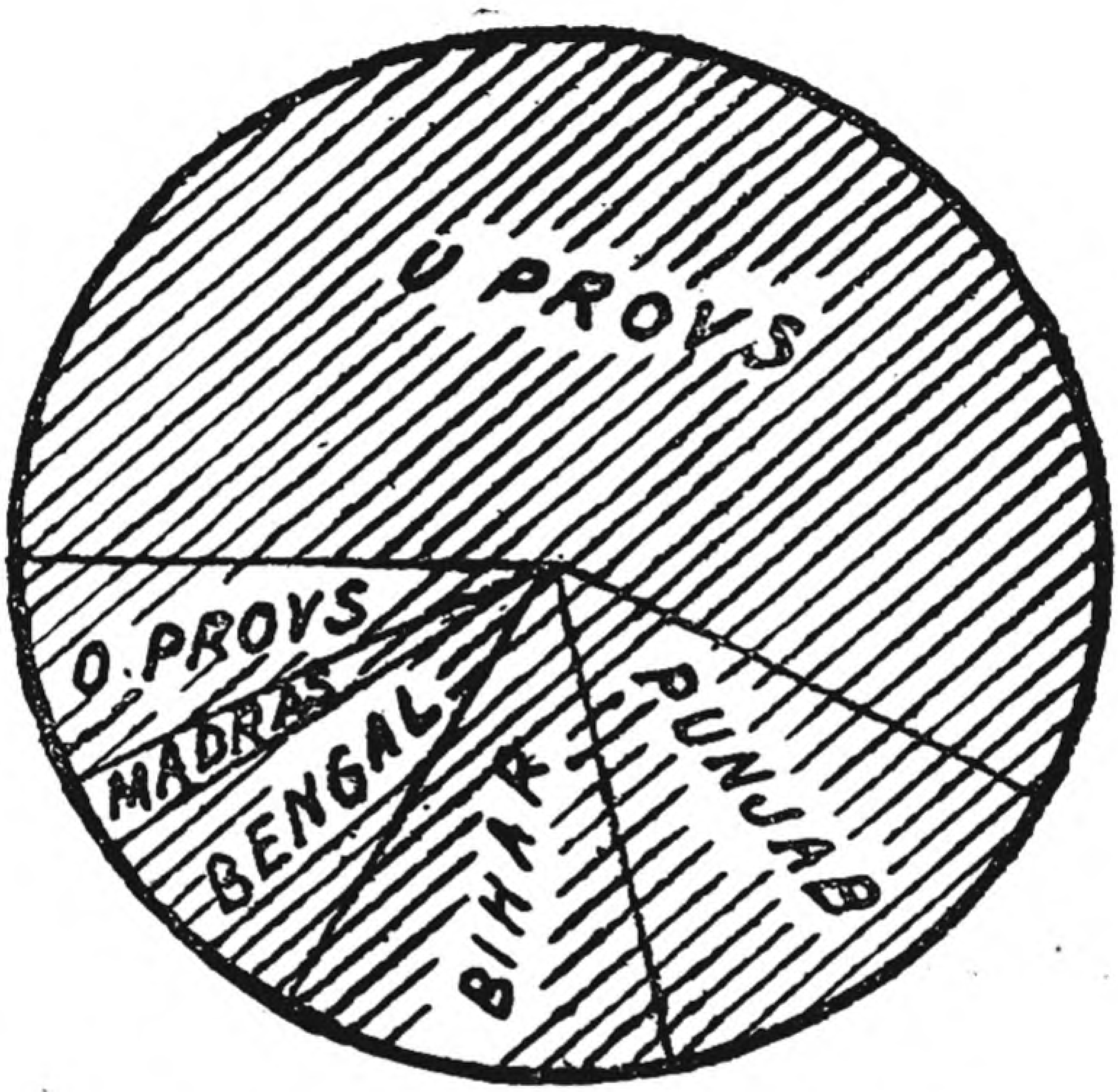


Fig. 8—Showing Provincial Acreage Under Sugar Cane.

The three provinces, viz., the United Provinces, Bihar and Orissa are responsible for about 73 per cent. of the cane under improved varieties. The percentage of recovery of sucrose is gradually improving, the maximum being about 10 per cent., but yet it is certainly below the recovery from sugar cane in Java, where extremely high yields of sugar cane are obtained as a

result of application of fertilizers, irrigation, careful selection of the seed, and skilful cultivation.

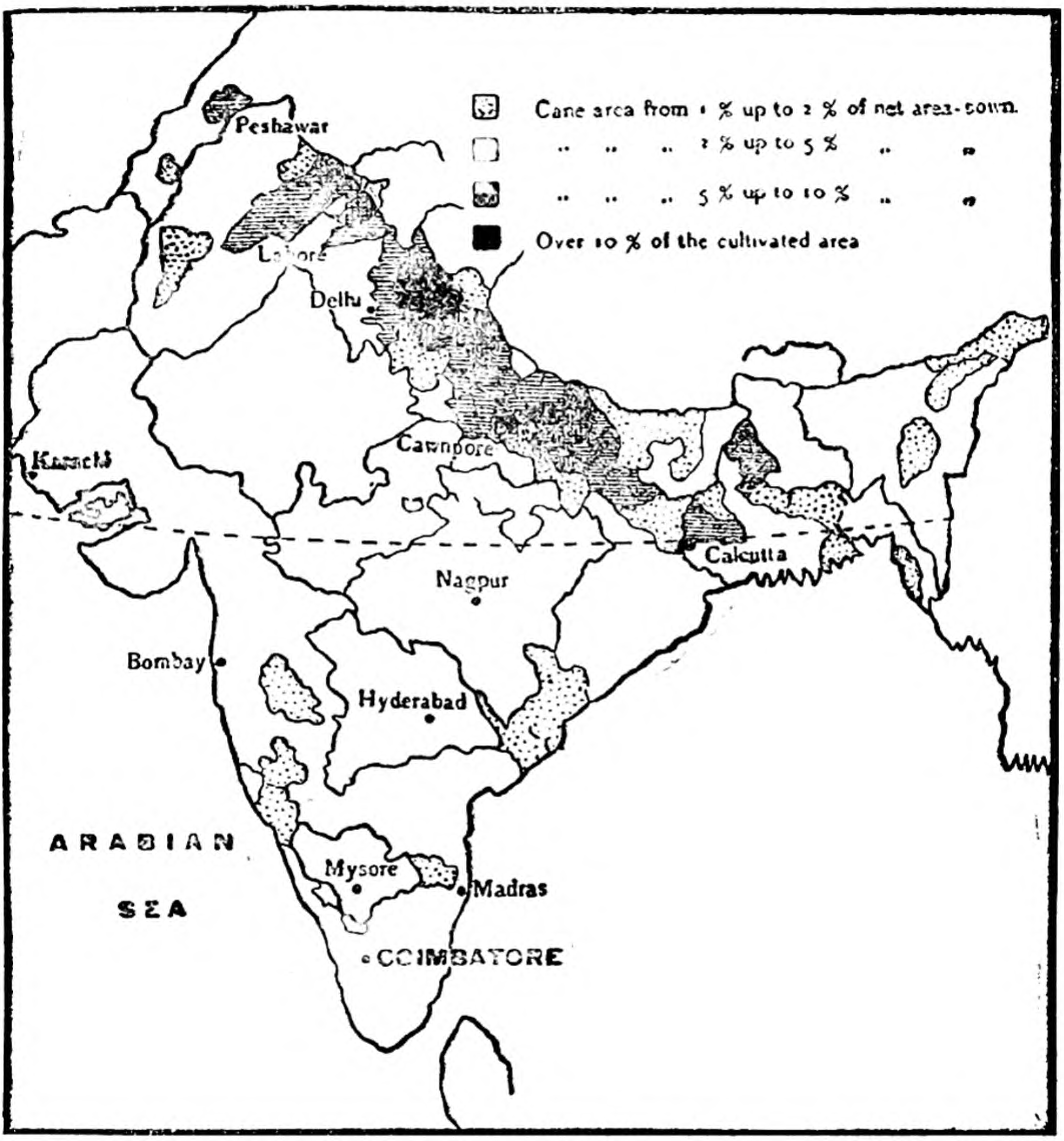


Fig. 9—Showing the Percentage Area of Sugar Cane of the net area sown in different regions.

Soil and Climate:— Sugar cane prefers a heavy soil but it also grows on lighter soils where abundant moisture and organic matter are available. Being a tropical plant it naturally prefers a somewhat warm climate and it

flourishes in regions with an average temperature of 78° during the growing season and with a rainfall exceeding 55 inches. It needs plenty of water and where rainfall is inadequate, irrigation has to be provided. Naturally, the amount of actual irrigation would depend upon the rainfall of the region, the nature of the soil and the variety of sugar cane grown. It also requires heavy manuring. It requires a long growing season, which in India varies from 10 to 12 months.

Ratooning :— In case the root stocks on cutting the cane are left in the soil, they produce another harvest. The crop grown thus is called the first ratoon, while the second crop is known as second ratoon. Thus harvests for about 30 years are possible, but generally about five are matured. But in India this procedure is not very common. Although this method saves the trouble and cost of planting, yet it has been observed that the yield diminishes gradually and the plant is likely to be infested with disease.

Fluctuations in Acreage :— It is noteworthy that until 1932 the area under sugar cane remained very stable, which varied from 2½ to 3 million acres *per annum*. With the grant of protection, referred to above, the area under sugar cane definitely began to increase. This increase was undoubtedly connected with the greater demand for sugar cane by the white sugar manufactories. In the year 1936–37, the area under sugar cane increased to about 4,500,000 acres. In this year there was a bumper crop which produced a record yield. The factories crushed to their full capacity which

resulted in the over-production of sugar. This brought about a fall in prices of sugar and cane. The area under sugar cane dwindled greatly in the two subsequent years of 1937-38 and 1938-39. The Indian Sugar Syndicate had been established in 1937. To prevent unfair competition, the Syndicate fixed minimum prices of sugar and allotted delivery quotas to regulate the sales of the members' sugar. This prevented further deterioration.

In 1938-39 the U. P. Government fixed attractive prices for sugar cane and thus the area under sugar cane increased again in 1939-40. It registered further increase in 1940-41. As a result of over-production of sugar, the Governments of the United Provinces and Bihar decided to restrict the production of sugar in these two provinces by the allotment of crushing quotas to factories. There was poor demand for cane and its price decreased to 4 annas 6 pies per maund. This again brought about a decrease in acreage in the year 1941-42 and the Government again allotted crushing quotas. The production of sugar was poor but the demand owing to the War had increased. To cope with this excessive demand, the Governments of the United Provinces and Bihar abolished control and encouraged growers and factories to a maximum effort. This naturally meant an increase in the area under sugar cane in the year 1942-43.

Thus since the year 1936-37 there have been remarkable fluctuations in the acreage under cane. High prices of sugar cane have generally meant an increase in the area resulting in its over-production which brought

about the lowering of prices of sugar and thereby cane also. Such a state of affairs resulted in shrinkage in the acreage under cane.

Yield :—In this country the average yield is 15 tons of sugar cane to an acre but according to Dr. W. Burns[1] yields of 30 to 55 tons are possible, depending upon the climate, soil, manuring and irrigation facilities available.

1. *Op. cit., p. vi*

CHAPTER V

Agriculture and Agricultural Commodities (Contd.)

OILSEEDS

India is the largest producer of oilseeds (see Fig. 10), which comprise rape-seed, mustard, sesamum, linseed, castor seed, groundnut, etc. The oils compressed from them are put to a variety of uses in the domestic economy of India and other countries. In the olden days they were used for lighting, cooking and a host of other purposes. Today the oils pressed are used both for edible and industrial purposes. Vegetable oils are increasingly used as lubricants, in soap making and in varnish and paint industry. The residue, which forms the oilcake, serves as a food for cattle or as a fertilizer for the soil.

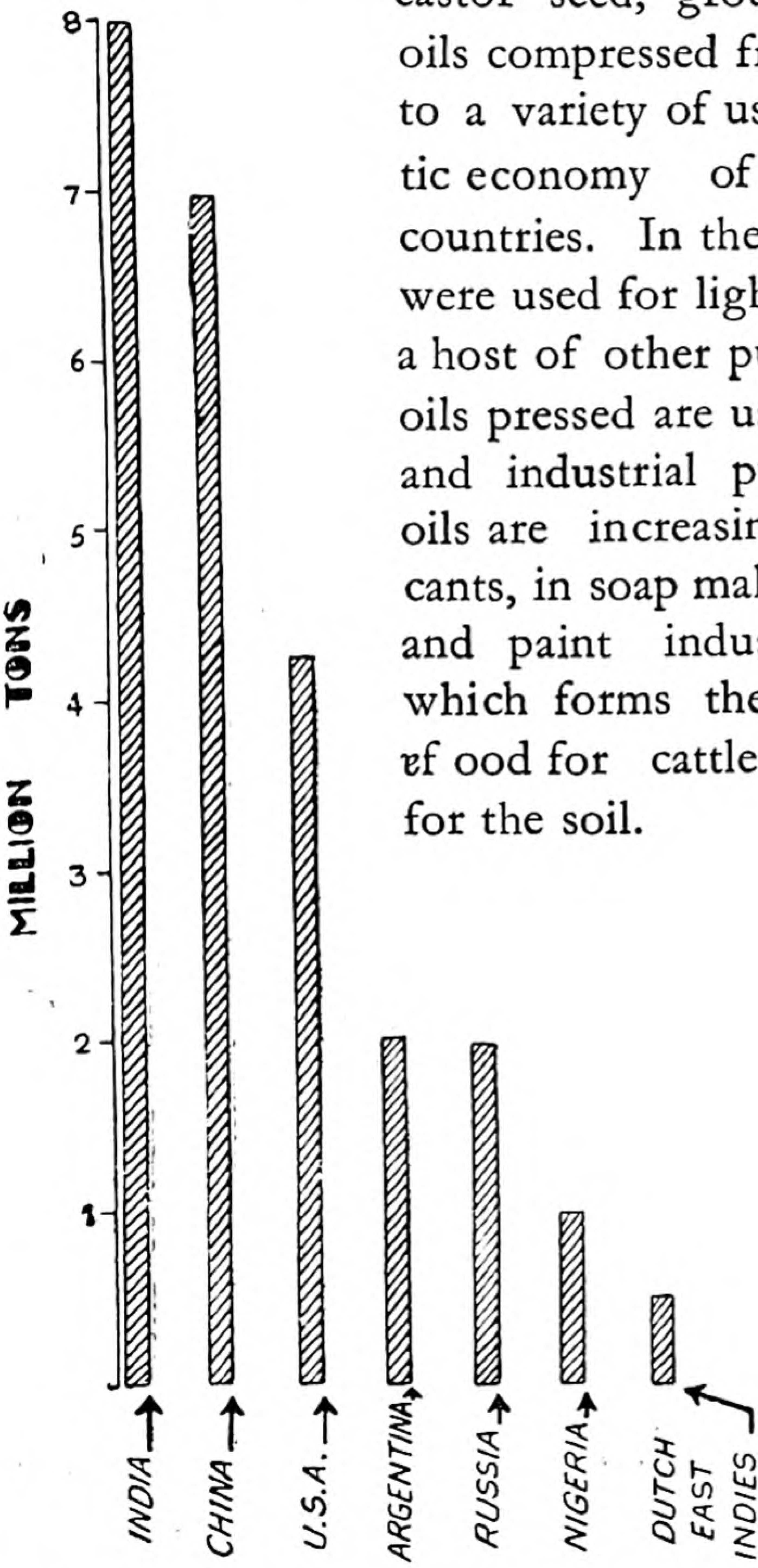


Fig. 10—Compares the Output of important Oilseed-producing Countries of the world.

Mustard and Rapeseed

The various kinds of mustard crops comprise *sarson*, *rai*, *toria*, *taramira* or *seoha* and are believed to be of European origin. Of these rapeseed (*toria*) is by far the most important. The United Provinces contain half the acreage, while the Punjab is the next important *toria*-producing province. The provincial distribution of acreage is shown in Fig. 11. They are grown as *rabi* crops in many parts, but more commonly in Northern India than in the South. The mustards are commonly grown as interculture with other crops like wheat, barley or gram; or like *toria* in the Punjab, they may be sown alone.

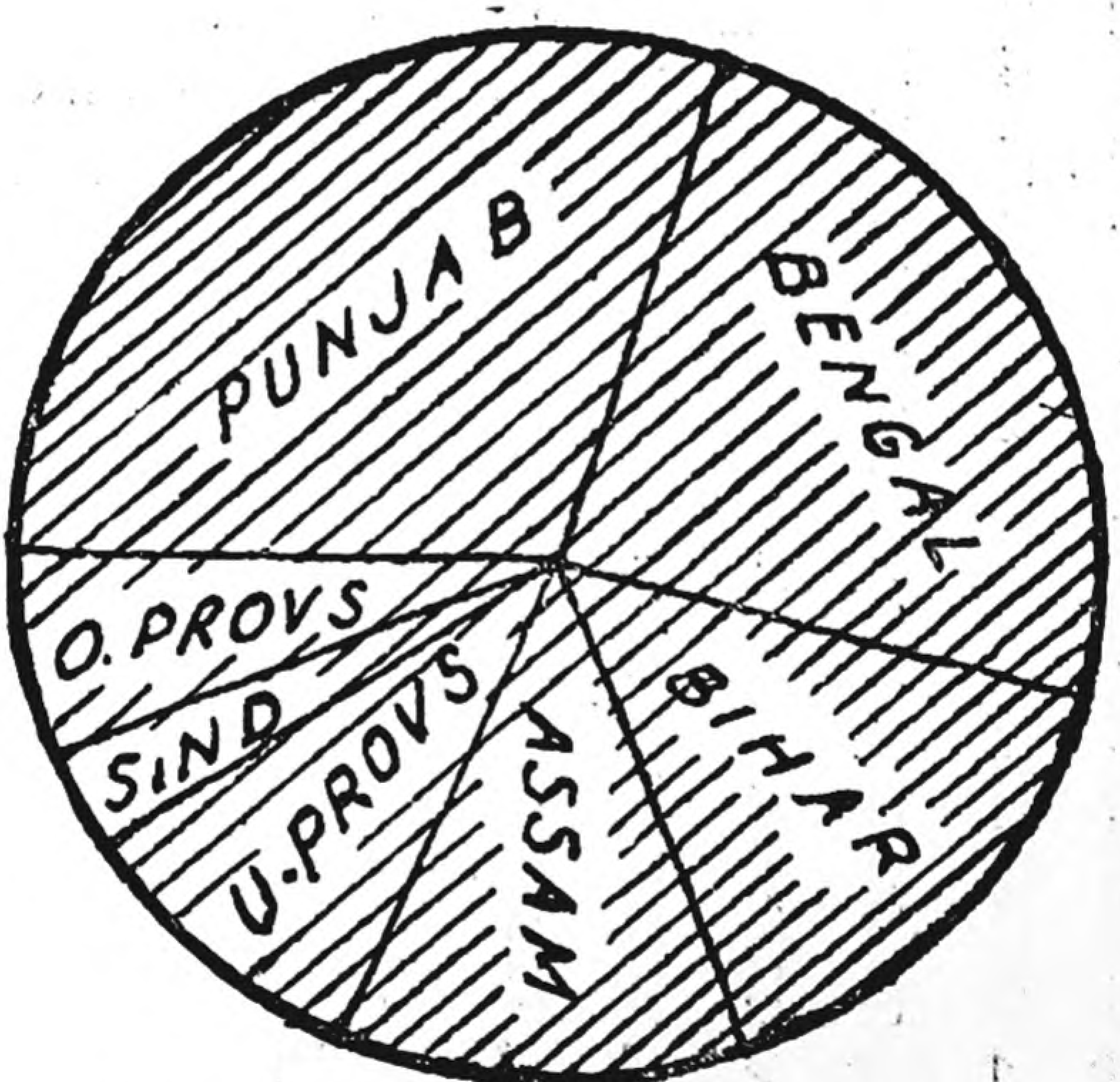


Fig. 11—Showing Provincial Acreage Under Rape and Mustard.

It has been found as a result of experimental work in the Punjab that application of 40 lb. of nitrogen in the form of ammonium sulphate, half at sowing and

half at flowering, increases the yield to 1,026 lb. as compared to 700 lb. in the non-manured area.

The total annual output of mustard and rapeseed in India is about 1,000,000 tons; the actual figure for 1936-37 is estimated to be 976,000 tons. Only a small amount of it is exported, while the remainder is consumed in India.

Sesamum

The original home of sesamum or sesame or *til* is believed to be South and South-western Africa. It subsequently spread northwards to Abyssinia and from there it came to India. Eastwards it spread to Burma, Indo-China, China and Japan and westwards to Western Asia, the Mediterranean region and North Africa. It is grown in many parts of India and the provincial acreage is shown in Fig. 12. In India sesamum is grown as a *kharif* crop in colder regions and as a *rabi* crop in the warmer regions. Well-draind fertile soils are naturally more suited, but it also grows on lighter and poor soils.

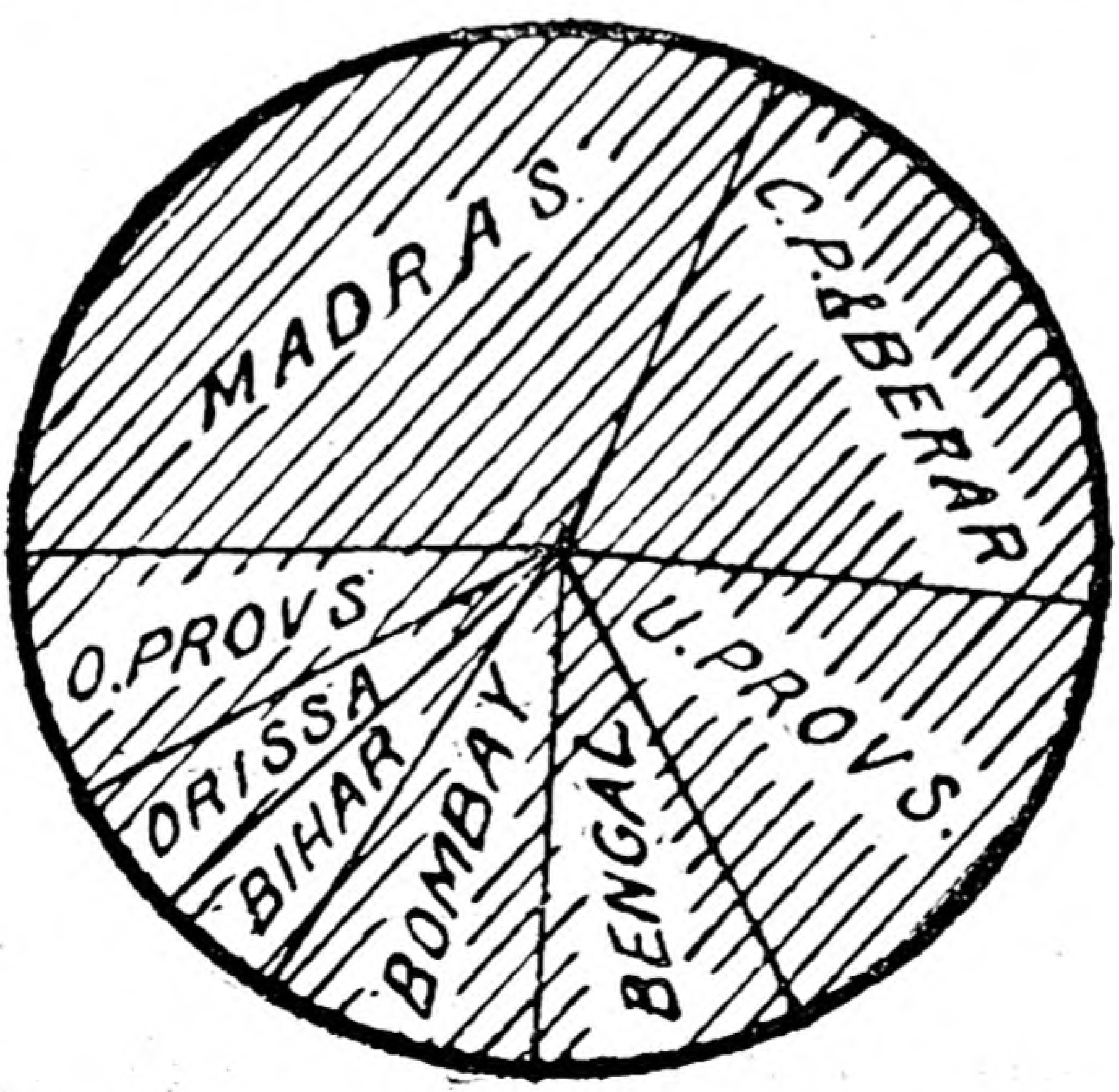


Fig. 12—Showing Provincial Acreage Under Sesamum.

The yearly outturn of the sesamum seed is about 480,000 tons produced from a total area of 5. 57 million acres in 1936–37. The exports are negligible as shown below :–

Year	*Quantity*	*Value*
1935–36	1,300 tons	$2\frac{3}{4}$ lac rupees
1936–37	14,000 ,,	27 ,, ,,

Linseed

Linseed, which is a *rabi* crop in India, is grown chiefly in the Central Provinces and Berar, Bihar, Orissa, parts of the United Provinces and Hyderabad-Deccan. The distribution of provincial acreage is shown in Fig. 13.

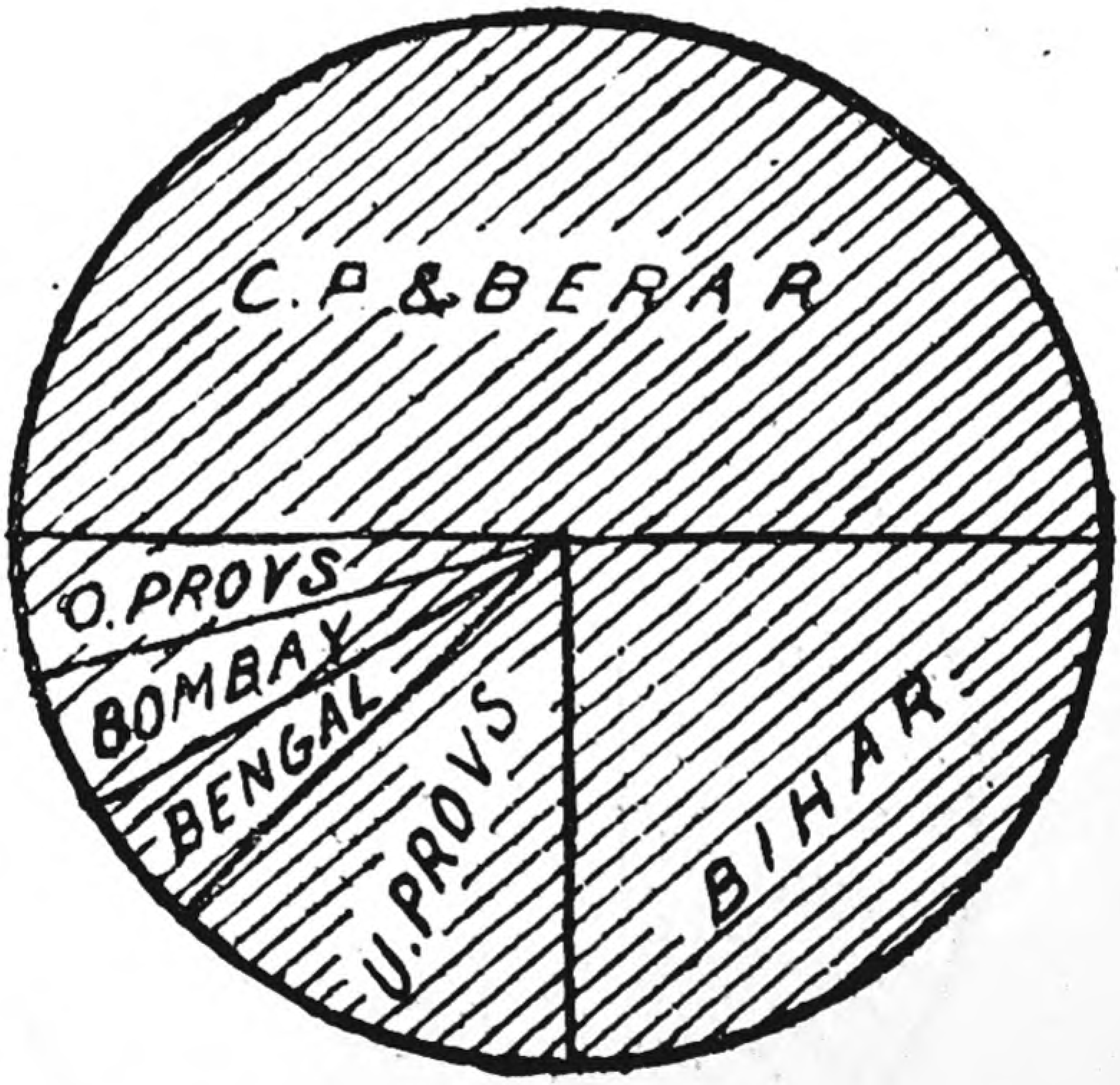


Fig. 13—Showing Provincial Acreage under Linseed.

The harvest is ready about the beginning of March and the yield varies from 500–600 lb. per acre. It prefers

a deep, heavier and moisture-retaining soil. There are two types : (i) the Peninsular type which is mainly grown on the Black Cotton soil, while (ii) the second type is grown on the Indo–Gangetic alluvium. This variety, as contrasted to the first type, is shallow–rooted, slow–growing and late ripening.

Linseed oil is used for industrial purposes, especially in the manufacture of paints. A very large proportion of India's yearly output is exported, although recently crushing mills for the manufacture of linseed oil for use in this industry have been established in India. India has been the largest exporter of linseed in the world but now its place has been taken by Argentina.

In 1936–37 total area under linseed was 3,594,000 acres with an outturn of 418,000 tons, out of which 296,000 tons were exported.

Castor Seed

The castor plant was originally a denizen of Africa and is now grown in all tropical and sub–tropical countries. In India it is grown practically all over the country; Hyderabad-Deccan is the largest producer, while Madras ranks as second. It is not confined to plains alone, but is cultivated at higher elevations also. The best varieties yield more than 50 per cent. of oil. In the warmer regions it is a perennial plant, while in colder regions and at higher altitudes it is an annual. It thrives best on loams. It can stand drought, but is very susceptible to water-logging and frost,

The castor plant, being a shrub or small tree, growing to a height of 10-15 feet, is cultivated on the edges of fields, but it is also sown as an interculture with other crops. The total output of castor seed in India is about 120,000 tons, and two-thirds of this production is crushed in the country for oil used chiefly as a lubricant, while the oilcake serves as a good fertilizer.

India was the premier castor seed-producing country in the world, but now its place has been taken by Brazil whose production is 50 per cent. greater than that of India.

In 1937-38 India exported castor seed-valued at Rs. 6,400,000 and 2,450,000 gallons of castor oil. Competition from Brazil and other countries is increasing.

The castor cake is not fed to animals because of its containing a poisonous principle, but it is a valuable manure.

Groundnut

It as an important cash crop of India and is beneficial in a rotation. The kernels can be directly eaten and oil can be manufactured from them which is greatly employed in the manufacture of *Vanaspati*. The oilcake has a high nitrogen content and is used as a manure and also for feeding livestock.

India is the largest producer of groundnuts or peanuts in the world. Its original home is believed to be Brazil. Although groundnuts were originally introduced in this country in the sixteenth century, yet the crop only made some progress with the beginning of

the present century. In 1937-38 the area under it exceeded 8 million acres. Other important producers of groundnuts are French West Africa, the United States of America and the Dutch East Indies. The world's total production of groundnuts is about 5 million tons, of which India's share is 3 million tons. The provincial acreage of groundnuts is shown in Fig 14.

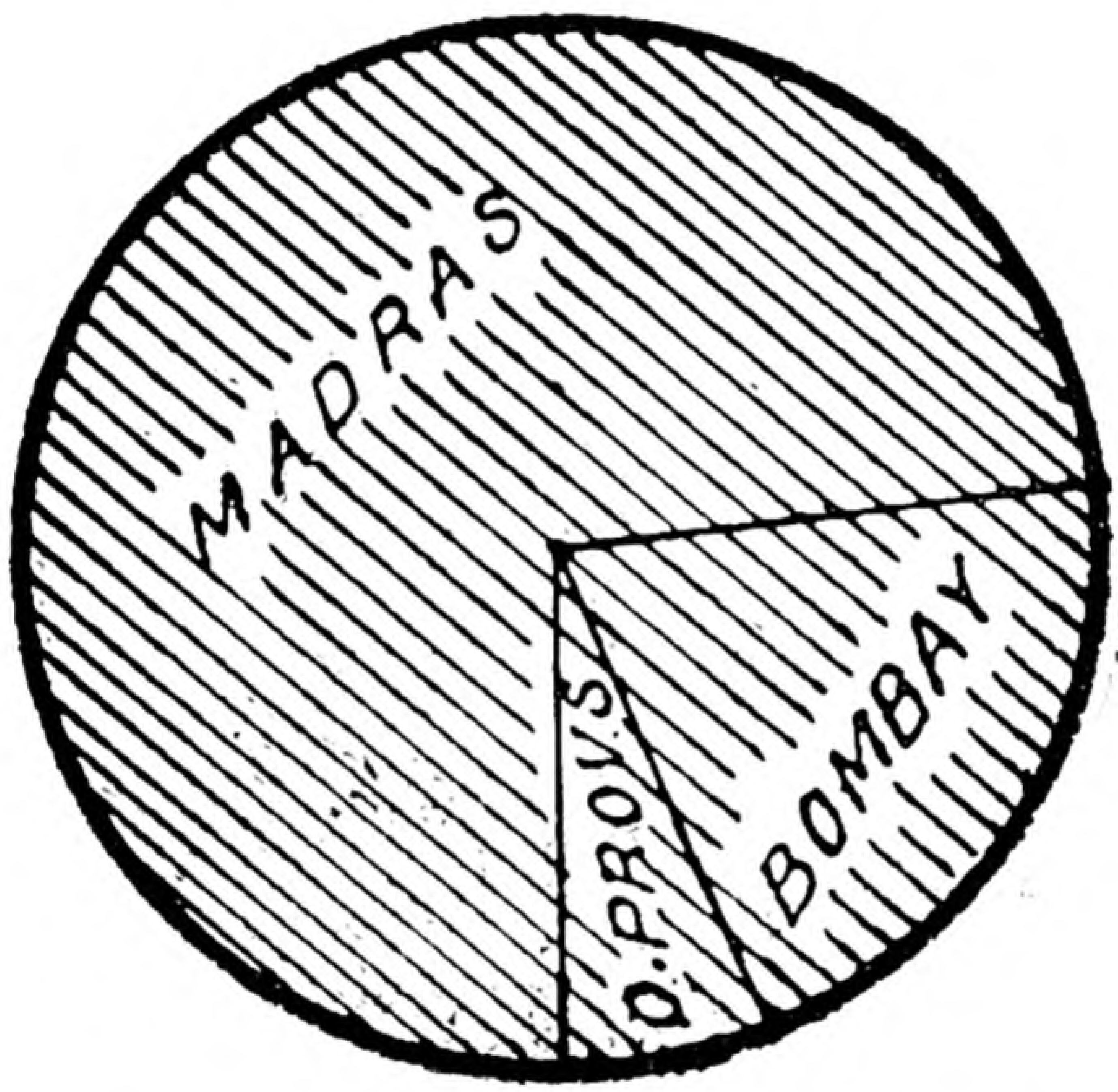


Fig. 14—Showing Provincial Acreage under Groundnuts.

The area under this crop in 1937-38 was distributed as follows :—

Madras	4.6	million	acres.
Bombay	1.34	,,	,,
Hyderabad State	1.48	,,	,,

Being essentially a tropical plant it needs a long and warm growing season. It is chiefly grown in regions with a rainfall of 20 to 35 inches *per annum*. A month of warm dry weather is essential during the ripening period. Frost is injurious to the

crop. The plant prefers light soils, but is also grown on the Black Cotton soil of the Madras and Bombay Presidencies, as also on the Red soils of Peninsular India. In the north it is also grown on the Indo-Gangetic alluvial soils.

For these reasons, groundnuts are cultivated all over India. It does well even on poor light sandy soils which would be practically of little utility for other crops. The writer has observed groundnuts being cultivated in actual sand adjoining streams.

Yield :— Below is given the yield of groundnuts in lb. per acre for some of the groundnut-producing countries of the world.

Name	1935	1936
Mauritius	2,230	2,230
Spain	1,972	...
China	1,499	1,668
Argentina	1,138	622
India	954	902
U. S. A.	758	758
Senegal	723	785

It will be observed that the yield in Mauritius, Spain and China is considerably higher than that of India. It may also be noted that the yield of improved varieties is higher than that of the local varieties. The improved varieties in Madras, e.g. A H25, has given a yield of 1,750 lb. per acre. Again, the new varieties AH685 and AH698 tried in Salem and North Arcot produced 50 per cent. higher yields above the local. Likewise the variety 477 in Hyderabad-Deccan yielded 49 per cent.

more than the local. It is concluded that the new varieties produced in Madras can at least produce 20 per cent. higher yields and are suitable for cultivation in several regions of India. The shelling percentage of average commercial samples is 71, while the yield of oil is 51.2 per cent.

In the opinion of Dr. Burns the annual yield per acre could be increased to 1,000 lb. per acre and 7 million acres could yield 3,120,000 tons against an average annual production of 2,822,000 tons only during the quinquennium of 1933–37.

The groundnut oil is used in the manufacture of margarine and is also an important edible oil. India is a large exporter of groundnuts, export in normal years being approximately 1,000, 000 tons. The balance of the crop, which is again in the neighbourhood of 1,000,000 tons, is used in India. The yield in 1936-37 was 2.8 million tons of which 7,39,483 tons were exported. The milling of groundnut oil in expellers and powerful presses is an important Indian industry.

The cake, which is a by-product of this industry, is also exported, the annual amount being nearly 300,000 tons.

Cotton Seed

In the cultivation of cotton, the seed is obtained as a secondary product. The yield of the seed is about two-thirds of the quantity of raw cotton or *kapas*. The total annual yield of the seed in India exceeds 2 million tons. The Punjab is the premier producer with 624,000 tons, while Bombay (380,000 tons) ranks next, followed

by the Central Provinces and Berar (290,000 tons). Generally, the Indian cotton seed contains 18 to 19 per cent. of oil. The cotton seed cake provides a good manure and is a food both for cattle and human beings. Cotton seed is also fed to bullocks and milch animals, particularly buffaloes.

Vegetable Oil Products

Vanaspati is being used in large quantities nowadays as a substitute for ghee, *vanaspati* being the market name given to the hydrogenated vegetable oil products. Within recent years this industry has developed considerably, the important centres in the United Provinces being Cawnpore, Ghaziabad, Begamabad near Meerut, etc. The other provinces, where *vanaspati* is manufactured in India, are Madras, Bombay and the Central Provinces. The industry consumes 2,700,000 maunds of groundnuts grown in India, besides other oilseeds like cotton seed, etc.

Cotton

India is the second largest producer of cotton in the world, the first being the United States of America. Cotton is cultivated practically in all provinces, but there are two well-marked cotton belts : the first is represented by the Black Cotton soil region, while the provinces of the Punjab, Sind and western part of the United Provinces, forming a part of the Indo-Gangetic plains, constitute the second region. In this tract the growing of cotton, particularly the sowing of long-stapled varieties has received great impetus owing to irrigation facilities. The distribution of provincial

acreage is shown in Fig. 15. The quality of cotton however, varies a great deal from area to area. As noted already, in the irrigated lands of the Punjab, Sind and

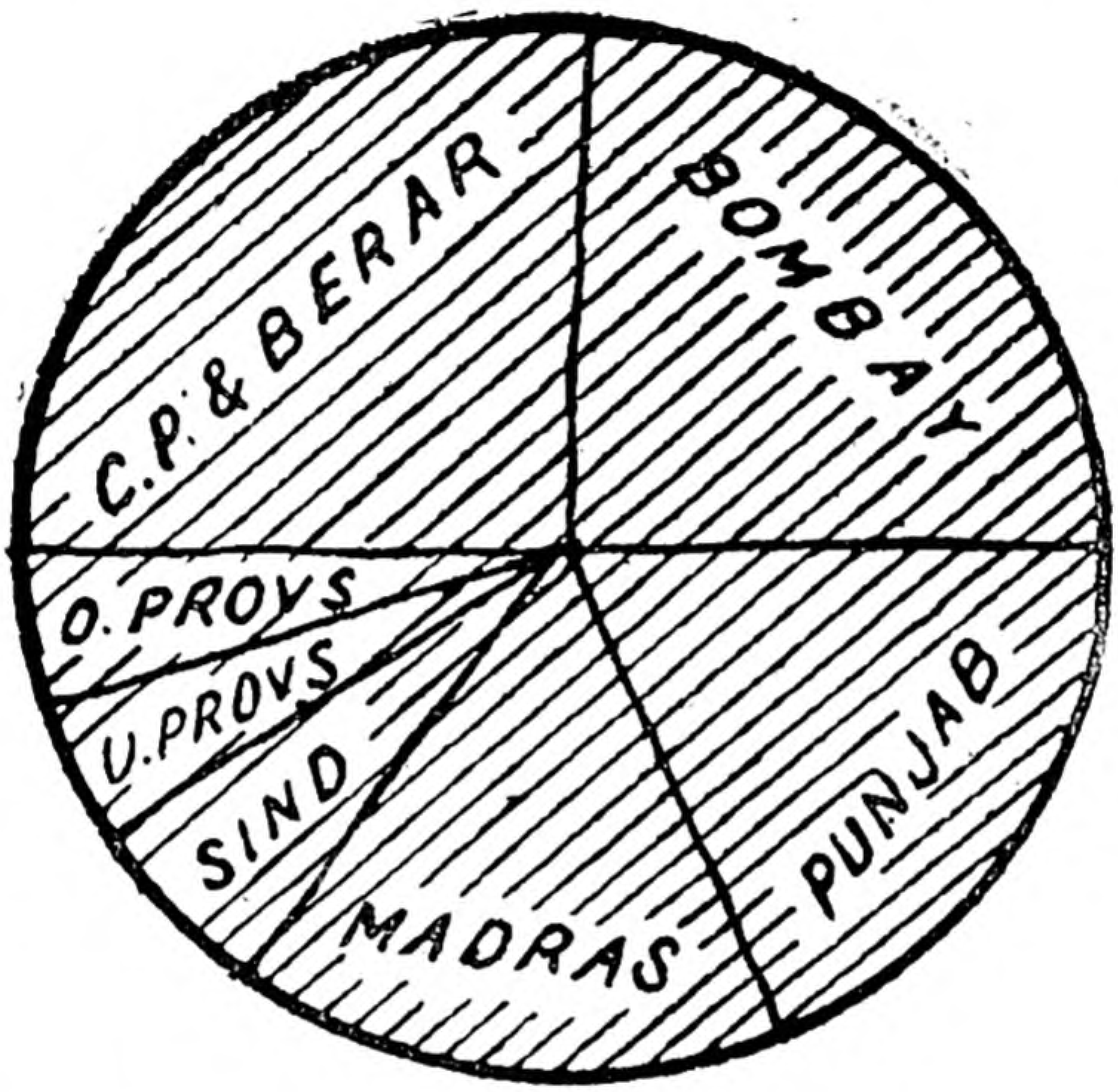


Fig. 15—Showing Provincial Acreage Under cotton.

Madras, now long-stapled acclamatised American cotton is grown, but in the remaining regions, which depend upon the monsoon rainfall, mainly short-stapled Asiatic varieties are cultivated. The long-stapled varieties represent about 22 per cent. of the total production.

In 1921 the Indian Central Cotton Committee was formed, whose work chiefly lies in co-operation with the Provincial Departments of Agriculture to improve the breed of Indian cotton and also to watch the handling and marketing of the produce.

Climatic and Soil Conditions :– Cotton plant is quite sensitive to its environment and consequently various

types or forms of cotton are grown in different parts of India. According to conditions of climate and soil, the indigenous cottons of this country may be classified into two groups :–

(i) the varieties which require five months to mature.

(ii) the varieties which take eight months to mature.

The first group is obviously confined to Northern and Central India where frost occurs during the cold season, while the second group flourishes in Western and Southern India which offer long-growing season without any frost.

Cotton prefers a warm, wet and equable climate, particularly in the early stages. During the harvesting season there should be clear weather as rains at this time will discolour the lint thereby deteriorating the quality. It flourishes best on the loamy soils, but it also grows well on clay loams.

Yield:—The yeild of cotton per acre in lb. in India is compared below to that of the important cotton-growing countries of the world:—

Egypt	531
Peru	508
Soviet Union	322
Anglo Egyptian Sudan	277
U. S. A.	264
Brazil	154
Argentina	151
India	89
Uganda	85

It will be observed that in Egypt and Peru, the yield of cotton lint per acre is about five times that of India. It has been suggested that the yield in India can be considerably improved by manuring, suitable rotation and control of pests and disease.

As noted above, the actual growing season is variable, but it is generally sown as a *kharif* crop with the advent of the monsoon. In the Punjab the sowing may take place in April with the help of irrigation. Picking commences in October and continues until the plants are killed by frost, but in the South the picking may commence from January to March and may last until July.

Output :– Bombay and the Central Provinces with Berar are the two leading producers of cotton in India. Other provinces comprise Madras, the United Provinces, the Punjab and Sind.

Although considerable improvement has been affected in the staple of the cotton in certain areas, but the yield of cotton per acre, as noted above, is very poor indeed.

The total acreage under cotton for the years 1933-34 to 1937-38 and the production of cotton in bales of 400 lb. each are given below.

	Acreage (In thousand acres)	*Production* (In thousand bales)
1933-34	24, 137	6, 192
1934-35	23, 972	6, 177
1935-36	25, 444	6, 837
1936-37	24, 769	7, 346
1937-38	25, 683	5, 544

It may be noted that the growing of the improved qualities, better manuring and suitable rotation of crops have helped to increase the yield per acre which is 14 per cent. above that of the previous decade.

The bulk of the Indian cotton, as remarked above, consists of inferior varieties and efforts are now being made to replace them by medium- or long-staple. In the Punjab and Sind, the area under American cotton comprised 2,425,000 acres during the year 1937-38. in the Punjab 4F is an established long–stapled variety. The production of some of the long–stapled varieties during 1937–38 is as follows :–

289 F	..	..	54,000 bales.
289 F/43	..	..	47,000 „
Punjab–American L.S.S.		..	50,000 „

In Sind from a variety named Sind Sudhar 77,000 bales were produced. Attempts are being made to bring a compact area of 300,000 acres of this American variety under cultivation.

A great success has attended the cultivation of long--stapled variety V 434 in the Central Provinces and Berar.

The Indian and foreign mills require cotton which will spin 20 counts and higher and naturally these varieties fetch high prices.

The average annual production of India may be reckoned at about 7,000,000 bales. It consumes half of its output in India and exports the remaining half. Bombay consumes 1,000,000 bales in its local mills and

exports 2,000,000 bales. Karachi is the next important exporting centre with a total export of 1,250,000 bales. About 2,500,000 bales are consumed by the mills elsewhere in India, e.g., Ahmedabad, Nagpur, Madras, Coimbatore, etc. and the remianing 750,000 bales are used in hand spinning.

In 1937–38 the peak figure of 2,993,838 bales of 400 lb. each was the total consumption of Indian cotton in the mills as compared with 2,631,296 bales in 1936–37 (including Burma upto March 31, 1937). The increase was due to the fall in prices and the Sino-Japanese war. The Bombay Presidency shared 62 per cent. of the increase.

Exports :– The average annual exports of Indian cotton are shown below :–

1923–28	3,439,000 bales.
1928-33	3,198,000 ,,
1933-38	3,319,000 ,,

India exports her cotton to the following countries, the pre-War percentage export being shown in each case.

Japan	51
United Kingdon	13
Italy	6
Germany	6

Scope of Improvement:— There is a considerable scope for improvement in the quality of cotton which would fetch higher prices in Indian and foreign markets and secondly attempts have to be made to increase the yield per acre by more intensive methods of cultivation.

Jute

Bengal has been the largest producer of jute from very remote ages. The area under jute has increased considerably. It now produces about 90 per cent. jute crop of India, while the remaining 10 per cent. is produced by the adjoining three provinces of Assam, Bihar and Orissa. Fig. 16 may be carefully studied in regard to the exact percentage provincial distribution of acreage under jute. India is practically the sole producer of jute.

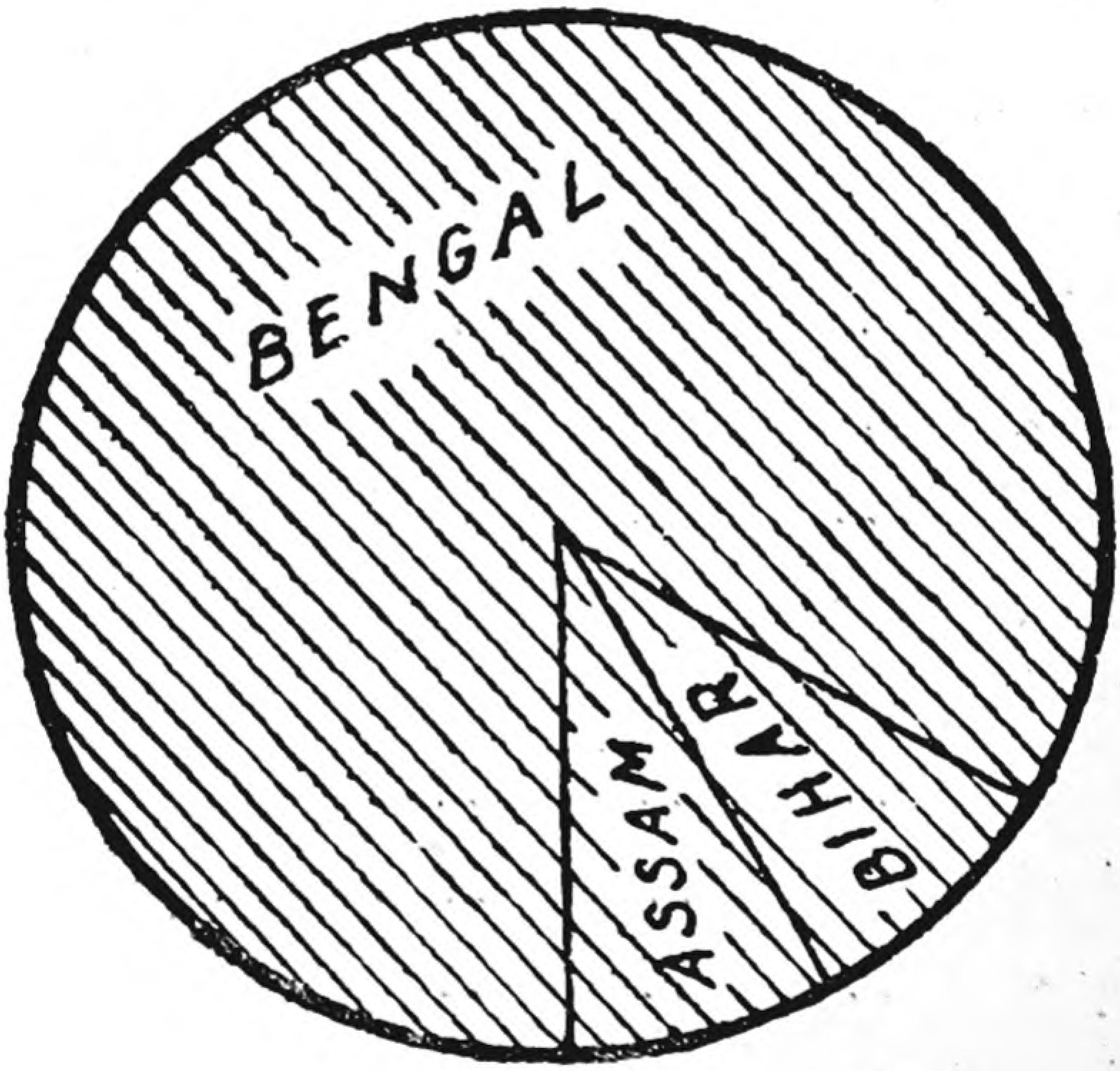


Fig. 16.— Showing Provincial Acreage under Jute.

Acreage under Jute:— In 1937, the total estimated area under jute was 2,861,000 acres as against 3,492,000 acres in 1930.

According to territory the acreage in 1937 was distributed as follows:—

Bengal	2,161,000
Bihar	445,000
Assam	198,000
Orissa	15,000
Cooch Bihar	42,000
Tripura	8,000
	2,869,000

Jute cultivation has been also introduced in the United Provinces, where about 10,000 acres are being sown. The fluctuation in acreage is due to (i) season, (ii) prices and (iii) restriction placed on the total acreage under jute. It may also be noted that price of paddy also affects acreage under jute. In case the price of paddy is abnormal, the cultivator obviously prefers to grow paddy instead of jute.

Climatic Requirements:—Damp soil and warm and moist weather favour jute cultivation. The plants flourish even when the fields are flooded with water but the water-logged soil affects adversely in the early stages. It has been found that the best fibre is obtained on loamy soil, while clayey soil produces the heaviest yield, but the plants do not ret uniformly. Sandy soil yields coarse fibre. It is, however, possible that the quality may be superior also as a result of better facilities for retting.

Jute is cultivated from late February to May depending upon the climatic conditions of the area and its height above river level. The plants take about three

to four months to mature. The height of a full grown plant varies from 6 to 10 feet but plants of 12-14 feet are common. It has been found that "locality, methods of preparation of fibre, and growth, environmental and seasonal conditions, rather than the seed determined the quality[1]".

Manuring :— Trials carried out by the Indian Central Jute Committe have shown that by the application of sulphate of ammonia and chloride of potash there is a substantial increase in yield and the latter also prevents stem-rot. A manure containing nitrogen, potassium and calcium proved the best and produced a yield of 20 maunds of fibre per acre as compared to 8.2 maunds with farmyard manure.

The Fibre:— The mature plants are cut down. After removing the leaves the stems are tied in bundles and immersed in water for "retting" which takes about two to three weeks. The fibre can then easily be stripped off from the stem. After washing it is ready for the market. The yield of fibre is only 5-6 per cent. of the green plant, when harvested.

Output :—The outturn varies a great deal, the best being from the Eastern Bengal. The average is stated to be 1,200 to 1,400 lb. per acre although much higher outputs are known.

The peasant disposes of gradually his stock to the petty merchants who dispose of their purchases to other merchants or to the agents of the baling firms in the district. These firms do the initial grading of the fibre

1. *Op. cit.* p. 93.

which they despatch to Calcutta. The sales are either effected by the big firms themselves or through brokers; further selection and grading of the fibre is done in the press houses of Calcutta according ro the overseas requirements. It is shipped in fully compressed bales.

Other crops, e.g. rice, are grown to provide food, although there may be surplus in some cases, but jute means cash. The jute trade had been affected very adversely by depression. During the quinquennium 1926–27 to 1930–31 the average annual value of the crop grown varied from £ 35,000,000 to £ 40,000,000, while during the period 1933-34 to 1937-38, the average annual value was less than £ 15,000,000[1]. About 1890 the annual output is reported to be 4,250,000 bales (each bale weighing 400 lb. net). In 1926 it was more than 12,250,000 bales. In 1931, however the production had decreased to 6,500,000 bales, while the annual figure for the years 1933–37 averaged 9,500,000 bales.

Scope for Improvement:— According to Dr. Burns[2] improvement can be affected in three ways:– (i) improved varieties should be only grown. (ii) Suitable manures should be applied which will result in bigger yields and less disease incidence. (iii) Standard technique of retting should be developed, which will produce fibre of better quality. The aim should be to obtain a yield of 20 maunds per acre with a standard quality of fibre. This would mean that only 2,250,006 acres will be required to obtain the yield of 9 million bales produced in 1943,

1. £ 1 = approximately Rs. 13/6/-

2· *Op. cit.*, p. 94.

thus releasing more than 1 million acres which could be devoted to the cultivation of food crops.

Exports and Buyers:— It is exported both in the raw and manufactured state. In 1928-29 the total exports were 898,000 tons with an approximate value of £ 24,250,000, but during the quinquennium of 1933-34 to 1937-38 the average annual exports decreased to 768,000 tons with a value of £ 9,750,000.

The chief buyers of raw jute are Great Britain and Germany, but France, the U.S.A., Italy, Spain, Japan and China and, in fact, all industrial countries are good buyers.

Synthetic Fibres

It may be noted that many types of synthetic fibres have been developed, which find numerous applications in industry. It is very likely that the synthetic fibres may affect the position of natural fibres, especially cotton. To avoid that, intensive research on all aspects of cotton has been recommended. A close watch has also to be maintained on the development of synthetic fibres and to study trends in production, prices and consumption, as the country is a large producer of natural fibres like cotton and jute on which the sustenance and prosperity of a vast number of cultivators and others associated with the industry depend.

Tobacco

The production of tobacco in India amounts to about 25 per cent. of the world's output. The actual figures for 1935–36 were 1,543 million lb., being 24. 1

per cent. of the world's production of 6,393 million lb.

Tobacco likes a hot and moist climate and is grown especially in the provinces of Bengal, Bihar, Bombay, Madras and Mysore State. India grows mainly two varieties of tobacco. The first is a coarse species which provides one--third of the country's requirements. It is consumed chiefly for *hookah* (hubble bubble) smoking. The second variety, which represents the remaining two–thirds of India's produce, is cured by drying in the sun. Besides smoking in *hookahs*, this variety is used in making cheroots or *bidi* (an indigenous cigarette), in which powdered tobacco is wrapped in a tree-leaf. It is also used for chewing or for making snuff. These varieties are not exported.

The modern development, i. e., the manufacture of cigarettes has provided a stimulus to tobacco-growing and half a dozen varieties of American origin are now under trial. It is this tobacco which is exported to the United Kingdom and represents the flue–cured Virginia tobacco, the seed having been originally imported from the United States of America. The Guntur district of Madras and the neighbouring Mysore and Hyderabad States, the United Provinces and Bihar have specialised in the production of this tobacco. Within the last decade, the area under this variety of tobacco in the Guntur district has multiplied more than twice. The quantity of cigarette tobacco produced in India in the last year, for which figures are available, is 99, 841,000 lb. This tobacco is taken to be produced on 110,188 acres and gives a yield of 906 lb. per acre.

In India there are two important tobacco-growing centres :—

(1) Bengal.

(2) Southern India—Madras and Mysore.

In 1935-36, the total area under tobacco was 1,357,000 acres.

According to Dr. Burns, given suitable conditions, total acreage under cigarette tobacco may be 200,000 acres producing nearly 150, 000,000 lb. of good flue-cured tobacco.

Exports :— This industry of exporting flue-cured Virginia tobacco has a considerable scope. In 1934 exports to the United Kingdom represented 9,500,000 lb. and in 1937 the exports were 14,500,000 lb. The reason for this expansion is in a small measure due to preferential duties on Empire produce, but the chief reason is that the importers in England found that Indian commodity was of good quality with reasonable prices and it could be used in manufacturing their old reputed blends maintaining the high quality. The total exports in 1935 were only 27 million lb.

Tea

After China, India is the second largest producer of tea. It was at the instance of Lord William Bentinck that in 1834 a serious attempt to grow tea in India was made and by 1852, the industry was well established. In 1865 the Government connection ceased and tea growing was left to private enterprise.

Tea grows in warm and moist climate, but in gently

undulating country where any excessive moisture is drained away. That is why it grows best on hill-slopes, where rainfall is frequent. Tea plant is a small bush, two to three feet high, but bushes of somewhat greater height are also known. The new tender leaves, which spring up during the monsoon rains, are plucked, dried, blended and packed. The industry is well organized now, having been in existence for about a century and has become an important industry representing about 8 per cent. of the total exports of India.

Tea-producing Regions:— Tea is largely grown in the north-east of India, particularly in Assam, Darjeeling, and the Naini Tal and Dehra Dun areas of Dooars. These regions produce about 80 per cent. of the total output of India, the remainder is grown in the hills of the Madras Presidency, the Travancore State and in the Kangra region of the Punjab.

Production and Export of Tea:— The area under tea before the War of 1914–18 was 600,000 acres, but the War, as in other cases, also gave great stimulus to this industry. The acreage was considerably increased and the coarser and inferior varieties were also introduced. In 1929, the area had increased to 750,000 acres. In 1936, the area under tea was 834,000 acres, which was distributed as follows:—

1. Assam	..	..	430,800
2. Bengal	..	..	203,100
3. Madras	..	..	77,700
4. Kangra Hills	..	..	9,600
5. United Provinces	..	..	6,500
6. Travancore	..	..	77,700

As a result of the increase in acreage there was a considerable over-production and the market was flooded. Then followed the great depression and drastic remedial measures were urgent. In May 1933, India, Ceylon and the Dutch East Indies entered into an agreement and decided upon a common scheme of restriction of exports, each country having its quota in proportion to its exports in the pre-restriction years. It was first apprehended that China and Japan, other great tea manufacturing countries, would take advantage of this restriction, but fortunately the fears did not materialise.

The exports of tea with their values for 1929-30, 1934-35, and the subsequent two years are as follows :

Year	*Export quota in million lb.*	*Actual exports in million lb.*	*Value in crores of rupees*
1929-30		376.63	26.00
1934-35	330.00	325.07	
1935-36	311.00	313.26	19.82
1936-37	309.00	302.86	20.04

In 1936-37 the United Kingdom received 85.6 per cent. of the total tea exports of India, which represented 77 per cent. of the total output, while the remainder represented the internal consumption.

In 1936-37, total exports from British India and the State of Travancore were as follows :–

United Kingdom............	257,094,000 lb.
Canada.....................	14,928,000 „
United States of America.....	7,868,000 „
Iran......................	10,963,000 „
Australasia.................	1,259,000 „

There is a great market for Indian tea in the United Kingdom, while the United States of America represent a great potential market. A considerable propaganda is done out of a cess levied on exports of tea by the International Tea Market Expansion Board in the U.S.A. to develop the potential tea market. Similarly, a great deal of propaganda is done in India ; nearly four million cups of tea are distributed *gratis* every month. This propaganda is again financed by a cess levied on the export of tea. In the United Kingdom, where drinking of tea is now a regular habit, the effort is to maintain the market rather than expand it.

Coffee

The origin of the first coffee plantation is not definitely known, but it is stated that one Bababudan in the beginning of the 17th century returned from a pilgrimage of Mecca with seven seeds which, planted near Chickmagalur, North Mysore, founded the Bababudan coffee. In the early days cultivation of coffee was a cottage industry. The East India Company had realised the possibilities of coffee trade and it was owing to their efforts that coffee plantations were started in Malabar. Plants were shipped from Portugese Goa to Brazil and this initiated the produce in South America which now controls the world market.

Coffee demands a rich soil, and a warm climate with a fair amount of rainfall. It grows on an average altitude of about 3,000 feet above sea level.

Coffee is largely produced in Southern India in the Madras Presidency, Mysore State and Coorg, the

Mysore product being the finest with the bolder character of the bean and finer cup flavour.

The total area under coffee is 200,000 acres and the annual output is about 20,000 tons. The superior qualities are exported to the United Kingdom, while the cherry quality is exported to France. Half of the total production is used in India, especially in the Deccan.

The Government of India levies a small duty on the export of coffee.

Fruit Culture

Fruit culture is an ancient pursuit in India. It produces indeed a very great variety and is believed to be the home of many of the finest tropical and sub-tropical fruits. India holds a monopoly in its mango crop of infinite variety. It also produces a large variety of oranges, those of Nagpur and Sylhet having the best reputation. Grapes and melons of Baluchistan, bananas, especially from Southern India, *lychees*, guavas and papayas from the United Provinces and Bihar, *malta* and other varieties of oranges from the Punjab are some other well-known fruits of India. Apples, pears, walnuts, and other fruits from Kashmir have a unique reputation, while apples are also grown in the Kulu valley as also in the region round Bhowali in the Naini Tal district of the Kumaun Himalaya.

Acreage under Orchards:— The acreage under fruit orchards is not accurately known as the Government statistics include the areas under vegetable and root crops as well. But the total area under fruits is estimated

at 2,500,000 acres. The areas under individual fruits are given below:—

Mangoes........	250,000	acres.
Bananas	150,000	„
Citrus fruits......	22,000	„

The fruit culture is a remunerative rural industry, but its organization is far from systematic. The plantations are not at all well kept and mostly the inferior varieties of fruits are grown. It would be certainly more profitable to grow standard quality fruits, which would fetch higher prices and find ready market at home and abroad.

Eating fruit is recommended for health and in this connection more production, quicker transit, better marketing and, in fact, everything that assists in providing cheaper and fresher fruits, are required.

Cold storage of fruits and vegetables promises another line of development and experiments in this direction already made at the Ganeskhind Fruit Experimental Station, Kirkee near Poona, have demonstrated the advantages of cold storage in the market as well as in transit. This process extends considerably the life of the produce as it slows down the life processes and retards the development of micro-organisms responsible for the decay.

Canning Industry

There has been a greater demand in recent years for fruit products, e.g., fruit juices, canned and

bottled fruit, jams and jellies and a large percentage of the requirements is met by imports from the United States of America, South Africa and Australia.

It, therefore, appears that there is a great scope for the development of canning fruit and preparing other products. In fruits like mango, of which India has almost a monopoly, it would be certainly paying to investigate the foreign markets for canned mangoes and its other products. Small start in this line has already been made in Bombay, Madras and the Punjab, but it is believed that this industry promises a tremendous scope, if organised properly.

Sweetened cordials and squashes, made from limes, lemons and oranges, jellies and marmalades from citrus fruits, grown in the country should also command a good market.

Drying of Indian Fruits

There is a considerable scope for the dried fruit and vegetable industry. This is a profitable method of disposing of surplus fruit grown in India. Drying has certain advantages over canning which requires costly equipment. Cans are expensive, sugar is dear and the frieght charges are heavy. The drying process is, however, cheaper and can be easily manipulated.

It may be noted that other countries, which grow fruit on a large scale, dispose of a high proportion in dried form. For instance, in California, 20 per cent. of the production is disposed of as fresh fruit, 15

per cent. is canned, while 65 per cent. is dried. A large variety of fruit, suitable for drying, is grown in the N. W. F. Province. The process has already proved successful there. India imports dried fruits of the value of Rs 900,000 from Afghanistan and a home market can, therefore, be easily developed. Likewise England imports dried fruits worth £8,000,000 and it should not be impossible to capture some of that trade.

Vegetables

A great variety of vegetables is grown in India. In the hilly regions of say Naini Tal, Simla, Kashmir, etc. a number of vegetables, generally grown in temperate countries, are produced. The scope of the work precludes their treatment here, but a brief description of the potato growing is given below.

Potatoes :— It is one of the most common vegetables of India, although it represents an important food crop of the world. It is a cool climate plant and in India it is grown in summer in the hills and in winter in the plains. It prefers loamy or peaty soils which are well-drained and are slightly acidic. It is grown in almost all provinces. In the Punjab, the important centres are Kulu and Kangra valleys and the Simla hills. It is grown in the neighbourhood of most important towns, where it finds a ready market. In the United Provinces, the important centres are the regions round Naini Tal, Almora and Mussourie, while in the plains it is grown in the neighbourhood of large cities like Luck-

now, Cawnpore, Allahabad and Benares. In the Presidency of Bengal it is grown near Darjeeling and in the districts of Burdwan, Hooghly, Rangpur and Jalpaiguri, while in the adjoining province of Assam, it is grown in the Khasi and Jaintia hills. The Poona district is an important centre in the Bombay Presidency, while the Nilgiri hills constitute an important region in the Madras Presidency.

Potato crop responds readily to manuring and with the application of suitable manures and fertilizers, the yield may be as much as 20,000 lb. per acre as in Madras, while the yield on unmanured land is given as 8,275 lb. These are the highest yields, while in Bombay and Bihar the yield on unmanured land is 15,000 lb. to the acre.

It has been demonstrated that potatoes, both for seed and consumption purposes, can be preserved in cold storage at 35° F. for at least nine months without undergoing any deterioration.

Cinchona

Cinchona tree, which is greatly valued for its bark, is really a native of tropical slopes of the eastern Andes in South America. Various extracts are prepared from its bark, but quinine, a very effective remedy for malarial fevers, is the most important.

In India a Government plantation was established in the Nilgiri hills and another one in Darjeeling in the very wet parts of the eastern Himalayas. The supplies from other countries is only 10 per cent., while Java at

present supplies the remainder, holding, therefore, a virtual monopoly of the drug.

Indigo

Indigo plantations were flourishing in India before the introduction of synthetic dyes. In India it is made from a plant, which flourishes in warm and wet climate. The chief indigo–producing provinces are Bihar, Orissa, Madras, the Unitd Provinces and the Punjab. It is used for dyeing and tanning purposes.

Opium

Opium manufacture in India is declining in accordance with the policy of the Government which hold a monopoly for poppy cultivation which is confined to the United Provinces, Bihar, Central India, etc. There is an important factory for the manufacture of opium at Ghazipur in the United Provinces.

Conclusion

Indian agriculture has to play a very important role of feeding nearly one-fifth of the total population of the world. Connected with it there are many problems which need both official and unofficial whole-hearted attention. Soil survey and land utilisation survey have hardly received any attention in this country yet. In case greater yields from land are to be obtained we must know our soils, and they should, of course, be put to the best advantage of the sons of the soil. The prevention of soil erosion and the conservation and improvement of soil have been referred to already in Chapters XVII

and XVIII of Part I of this work. Reclamation of the Usar lands has been referred to already, as in the United Provinces alone there are five million acres of such lands besides extensive areas in the Punjab, Bihar, etc. With our vast population we can ill afford to lose any land. As noted above, cultivable waste other than fallow comprises 11,267,000 acres of land. Under the present circumstances, it deserves all our endeavour to bring this land under cultivation. The Government of Sind have prepared a scheme for establishing State farms on Government-owned waste lands in the province. The Department of Agriculture will establish estates, each measuring about 4,000 acres, which when sufficiently developed, will be sold either to the *Zamindars* or divided among a number of educated unemployed youths, who would be taken up on such farms. The scheme will serve three-fold purpose : first it will help in the development of waste lands, secondly it will help in the demonstration of modern methods of agriculture to *Zamindars*, and finally it will assist in solving at least to some extent the problem of unemployment among the educated youth of the province.

In Chapters II and III of the present Part, the problems of irrigation and the conservation of water have been dealt with. Besides these, agriculture in India must be carried on on an intensive scale in order to raise more crops from the land. For this the improved methods of agriculture with the modern machinery must be adopted, wherever possible. There is the difficulty of small holdings in India, but in advanced countries there is the plan of co-operative farming. In some advanced

countries there is even the idea of the State buying all land and then nationalising agriculture. Finally, the cultivation of improved varieties of seeds must be extended further so as to bring all land under improved varieties. Livestock is another problem closely connected with agriculture. So long the bullock is not replaced by machinery, it should be our endeavour to have superior breeds of animals which do their task well and better.

CHAPTER VI

LIVESTOCK AND RELATED INDUSTRIES

The extent of income to India from cattle and cattle products is hardly realised, which is given below :—

		Value in rupees
Milk and Milk products	...	504 crores
Cattle Labour in agriculture	...	408 „
Cattle manure	...	180 „
Labour for purposes other than agriculture	...	107 „
Hides and skins	...	40 „
	Total	1,239 crores

It may be noted that this estimate is not exhaustive as it does not take into account the cheap cattle dung fuel used so largely in the country. It also does not take into consideration the products from wild animals, (e. g. elephants), pigs and lower animals including poultry, fish, etc.

Animal Husbandry

India is mainly an agricultural country where agriculture still depends mainly on the bullock which is practically the only source of traction power. The cattle like the cow and buffalo play a very important role in the life of the country. There are 205 million

cattle in India, which comprise about one-third of the world's total stock of cattle and two-thirds of the buffaloes. Besides, there are about 97 millions of sheep and goats. The agriculture, as noted already, is still carried on mainly in small holdings. The vitality of these animals depends upon the climate of the area and the quality and the quantity of the nourishment they receive. Until recently the improved breeding of the cattle was almost neglected and in years of famines of fodder, cattle mortality must be indeed very high. Further, owing to increase of the pressure of population on the land, pasture lands are rapidly being brought under cultivation for food crops. It is not easily possible to import fodder from other countries owing to its bulky nature. Hence the usual effort should be to raise such crops which would yield bigger quantities of both grain and fodder.

The cattle of the cotton belt of the Central Provinces, which are stall-fed and where *jowar* is raised as a fodder crop, are decidedly better both in draught and milking capacities than those of the rice belt which have to depend on grass of lower nutritive value.

Too much rainfall, as on the West Coast of India and in Assam, etc., is not conducive to strong and better breeds of cattle, which are reared in regions with moderate rainfall, good drainage and where there are good stretches of pasture lands. It is in such regions that the best cattle of the Deccan are found in Nellore, Mysore and Coimbatore.

Based on climate, which forms a very important factor in the environment of cattle, India may be divided into three regions (See Fig. 17). The first

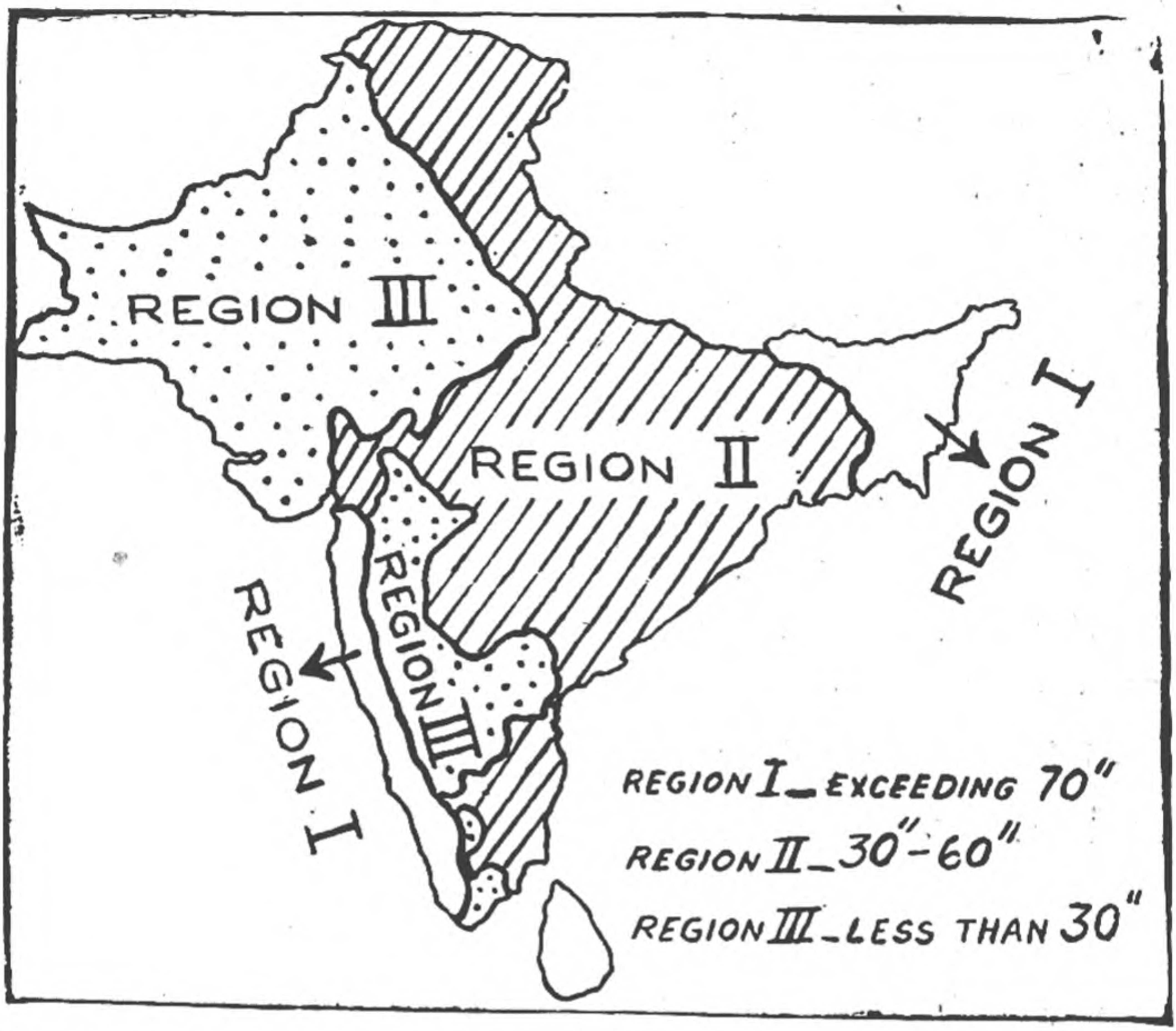


Fig. 17—Showing the three Climatic Regions of India which have a great influence on the rearing of cattle.

region has a rainfall exceeding 70 inches and comprises Assam, Bengal and the West Coast of India. The second region has a moderate rainfall of 30 to 60 inches and represents the middle of the country. The third region has a rainfall of less than 30 inches and comprises North-West India. Even in these regions physical features make the conditions somewhat variable. However, these regions form distinct units where live-stock have their characteristic traits. For instance, it has been estimated that the capacity of cattle for milk

production in these three regions is 370 lb., 462 lb. and 773 lb. respectively. The same is true of the working capacity of cattle. It is stated that a pair of bullocks can help to cultivate 7-6 acres of land in the first region, while the same figure for the third region is 19.2 acres.

Gujerat :--The Gujerat cattle are believed to be the best in India. The land possesses many natural advantages. In the State of Junagadh, the Gir cattle from the forest regions are famous for giving large quantities of milk.

Punjab :—The Punjab is famous for its two breeds of cattle. The first are those of Hansi Hissar of the Eastern Punjab, while the other are known to come from the Montgomery district which has extensive pasturage, and the canal irrigation has helped the cultivation of leguminous crops.

Buffaloes

In India buffaloes play an important role both as draught and as milch cattle, but they are slow of motion. The buffaloes of the Punjab, especially the Murrah and the Rohtak cattle, are good lactation animals. It has been found that one buffalo yields milk equal to two cows. It is stated that their milking capacity varies from 732 lb. in the first region to 1,615 lb. in the third region. The percentage of milk produced in India is as follows :—

Buffaloes..............60 per cent.
Cows .:...............37 „ „
Sheep and goats ....3 „ „

As stated above, the milking capacity of buffaloes can also be augmented by better feeding and application of scientific methods.

Animal Industries

There are a host of animal products which are of industrial importance, e. g., milk, meat of various animals, fat, blood, bowels, offal, horn, hoof, glands, bones, hides, skins, furs, feathers, wool, hair, bristles, silk, honey, lac, ivory, fish, fish-fins and maws, pearls, shells, coral, dyes, and excreta. The above constitute raw materials for many important industries, some of which may be enumerated below :—

(a) Food industries.
(b) Leather industry.
(c) Textile industry.
(d) Manufacture of fertilizers.
(e) Lac industry.
(f) Pharmaceutical industry.
(g) Button, Comb, etc. industry.
(h) Sport goods.
(i) Dyes, glue, etc.
(j) Decorative articles.

Food Industries

Important foodstuffs, {provided by animals, include milk and milk products, meat, fish, poultry, etc. Connected with these are dairy-farming, sheep-rearing, poultry-farming, development of fisheries, pig-rearing, etc.

Dairy-Farming

Dairy-farming in India is largely the work of individuals and is carried on on a very small scale. With the concentration of large population in cities, the problem of milk supply has become very acute. The development of dairies on scientific lines is the crying need of the towns and cities of India. In India milch cattle and buffaloes comprise 53 millions. Sheep, goats and camels represent, as noted above, a very minor source of milk. It amounts to about 6 ounces of milk *per capita* daily. This quantity is, however, too small for an average vegetarian who needs about 20 ounces of milk daily. Although this represents increasing three times the present supplies of milk, but this does not seem impossible, if the breeding of proper pedigree milch cows and buffaloes is planned and encouraged.

The quality of cattle and their milking capacity can certainly be improved by (i) feeding , (ii) pedigree breeding, (iii) management and (iv) eradication and control of disease. It is suggested that an increase of 30 to 50 per cent. of milk is possible by better feeding. Improvement by breeding is a somewhat slow process, but in the third region by scientific and pedigree breeding there has been an increase of 400 per cent. in about 25 years. Likewise by better management their calving interval can be reduced at least by about 15 per cent.

It is estimated that the total milk supply of Calcutta is 4,000 maunds daily which amounts to 2-3 ounces per head. The best plan to improve the milk supply of large cities would be to start dairying in the suburb-

an villages with rapid means of transport. On these lines the Co-operative Milk Union in Calcutta has been so organized that milk obtained in villages within a distance of thirty miles is collected and pastutised for sale to the public. It handles supplies of milk which can be further augmented with the help of refrigeration and better transport facilities.

Ghee Industry

In India, most of the butter obtained, is rendered into *ghee* by boiling. There are, however, a few firms in India like Messrs Polsons of Bombay, the Keventers of Aligarh, etc. who sell butter, both fresh and pasturised in tins, etc. Other dairy produce such as cream- or cheese-making on any large scale is still unknown in India. *Ghee*-making is the traditional industry of India. It is naturally produced in those regions which have good breeds of cattle with good pasturage facilities and where naturally the population is not very dense. The Punjab produces large quantities of *ghee*, but only small quantities are exported to the adjoining provinces. The United Provinces, Rajputana, the Central Provinces, Madras and Mysore have a large export trade. The annual exports of *ghee* from India to Aden, Mauritius, South Africa, Ceylon and Hong Kong are estimated at Rs. 25,00,000. The provinces of Sind and Bombay, however, import a little *ghee* from Turkey and East Africa.

Unfortunately, the adulteration of *ghee* has become a common practice and not only several vegetable oils are

mixed, but sometimes harmful oils of *Mahua* and castor are added.

Sheep-Rearing and Wool Industry

In India about 47,000,000 sheep are reared both for their meat and wool. The cold climate in winter in Northern India necessitates the use of woollen clothing. In India sheep are reared in areas where good pasture lands exist or on the borders of the forests or in the forests where grazing is allowed. Although in some countries different species of sheep are reared for their mutton and wool, yet in India, as noted above, it is done for the two-fold object of obtaining mutton and wool.

The sheep-rearing is carried on extensively in the Punjab and North-West Frontier Province. In Bengal and Bihar the sheep are sent to the jungles for grazing in winter. It is noteworthy that the sheep of high altitudes, viz., those of Kashmir, the North-West Frontier Province, the hilly tracts of the Punjab, the United Provinces and Bengal are good producers of white wool. It may be noted that the output of white wool can be doubled by the application ot scientific methods.

Quality of Wool:—The sheep of Northern India yield better and whiter wool than those of Southern India, but the wool, in both cases, is of short staple. It is, therefore, not possible to spin yarn of higher counts. This fact, coupled with careless handling of Indian wool, is responsible for low prices obtaining in Europe as compared to the Australian commodity.

Output and Centres of Wool Production :—The yield *per capita* of Indian sheep is also very low amounting to about two lb. only as compared to $7\frac{1}{2}$ lb of its Australian sister. The annual production of wool in India is about 85 million lb. of hair and wool, white and coloured. The most important centres of wool production in India are the Hissar district in the Punjab, Garhwal, Almora and Naini Tal in the United Provinces, the Kurnool, Coimbatore and Bellary districts of the Madras Presidency. Wool is also produced in the States of Bikaner and Mysore which has a woollen mill in Bangalore.

India imports large quantities of wool from Australia and Persia and a special variety from Tibet. The average exports of raw wool from India are about 50 million lb. *per annum*. About 75 per cent. of this is sent to the United Kingdom.

Goats

Besides sheep, India also rears goats both for their milk, but largely for their meat. Their number is reckoned at about 49,000,000, but only about 15 per cent. are milked. The average yield of a milch goat is given as 200 lb. *per annum*. In the first region the average yield is only 74 lb., while in the third region it is 297 lb. *per annum*. It is a common sight in some of the cities of India to see small herds of milch goats followed by their owner who milks the animal in the presence of the buyer. India consumes very large quantities of goat's meat.

It may be noted that a 50 per cent. increase in the average milking capacity of goats is possible by the application of methods noted in the case of cattle, etc.

Horses

India also rears horses in large numbers, the figure for British India for the year 1937-38 being 1,323,000. Although some are trained for racing and riding, yet a very large number is used for the purpose of transport, both passenger and goods. Conveyances driven by horses are a very common sight in almost all big towns of India.

Poultry-Farming

Poultry-farming is becoming very common, especially in Northern India. Poultry are kept both for their eggs and meat and this industry offers a tremendous scope for enterprise and improvement. In Government experimental farms foreign varieties of poultry are reared generally for purposes of demonstration. The number of poultry of different descriptions in India is 190,000,000. India has over 52,000,000 laying hens valued at Rs. 7 crores and the value of eggs sold exceeds 5 crores of rupees *per annum*.

It is remarkable that the production of eggs does not conform to the influence of climate, as noted above. The output is 12·6 eggs per year per head of human population in the first-region, 5·7 in the second region and 3·6 in the third region. It is noteworthy that the produce is definitely higher in regions which breed poor livestock.

According to Dr. Burns 160 per cent. increase is possible in the annual production of eggs from indigenous hens by the application of scientific methods in their rearing. According to the same author at least 80 per cent. increase is possible for the country as a whole.

Hides and Skins

Leather has numerous uses. It is largely used in the making of foot-wear, both Indian and European, saddlery, bags, suit cases, and water buckets for irrigation purposes, etc. Among the minor uses mention may be made of leather for bookbinding, musical instruments, etc.

India produces more than 25 million raw hides every year. Out of these 6 million are exported as raw hides and 4 million as half-tanned ; the latter are despatched almost entirely to the United Kingdom which receives more then 50 per cent. of India's exports of hides and skins.

India is known to produce 48 million of goat and sheep skins annually. About half of these are exported in the raw state and 9 million as half-tanned dressed skins. More than two-thirds of the raw skins are exported to the U. S. A., while 15 to 20 per cent. go to the United Kingdom. It is noteworthy that more than 80 per cent. of the half-tanned dressed skins are imported by the United Kingdom.

The finer breeds of Indian cattle produce good hides. In India cattle are usually reared for their milk

and also for working in the fields. Naturally, the regions, where finer breeds of cattle are reared, are also good hide-producing areas.

The collection of hides is in the hands of the village *chamar* who does it in a very primitive fashion.

Tanning:— Vegetable tanning materials are available in abundance in India, but, however, vegetable tanning is a lengthy process taking six months for ox and buffalo hides and four weeks in the case of skins. There are about 500 tanneries in the provinces of Madras and Bombay which provide employment to 16,000 people. The discovery of chrome-tanning has greatly altered the industry. This tanning agent is a basic salt of chromium and the tanning takes only four weeks which is all done with the aid of machinery. The most important centres of chrome-tanning are Agra, Cawnpore, Calcutta and Madras.

Exports:—With the beginning of tanning in Madras, semi-tanned hides were exported to England, but from 1890 onwards Germany was the principal buyer. In order to keep the hides within the British Empire an export duty of 15 per cent. was levied.

The United Kingdom, Italy and the United States of America are the chief buyers of the Indian raw hides and skins.

Naturally, during the first World War of 1914-18 and as also in the Second War, the manufacture of boots for the Army received great impetus. This must have provided a stimulus to the leather industry and

the tanneries of India must have been worked to their utmost capacity.

Cattle Manure

Fertilizers and Manures have been treated already in Chapter XIX of Part I of this work. A brief account may here be given of the cattle manure produced in India. No exact figures can be stated, but a rough estimate of the green cattle manure, produced annually in India, is 839 million tons, and about two-thirds of this is burnt as a fuel for domestic purposes. No doubt, this is a very serious loss resulting in the poor nutrition of our soils. The remaining about 280 million tons, or about one ton of this manure per acre of cultivated land, is available *per annum* for nourishing the soil. However, similar manure from sheep, goats, poultry, etc. would be also available for the purpose.

CHAPTER VII

FISHERIES

In India there is only 0.72 acre of land *per capita* under food crops, which is quite inadequate for the purpose. Agriculture seems to have reached its maximum production under present conditions. Fisheries can, therefore, supplement food supplies and it is claimed that after agriculture and livestock, fisheries constitute the most important industry. It may be emphasised that the fisheries resources of India are very extensive and varied. They are extremely rich, both in regard to the variety and numbers of edible fish.

The chief fishing areas (See Fig. 18) represent the coastal margins of the sea, river estuaries and back-waters for marine and estuarine fish, and rivers, irrigation and navigation canals, lakes, tanks, ponds, *jhils*, and inundated tracts for fresh-water fish.

The coast-line of India is more than 3,000 miles in length and the total area of the continental shelf, i.e., between the coast and 100-fathoms line, is about 115,000 square miles, but only a small portion of this is exploited. Deep sea fishing is practically unknown.

Bengal, Bihar, Orissa and Madras are the important provinces which possess fresh-water and sea fisheries. The fishery wealth of Bengal is enormous. It is considered that the resources and potentialities of the fresh-water fisheries of Bengal are only excelled by those of the United States of America and Canada.

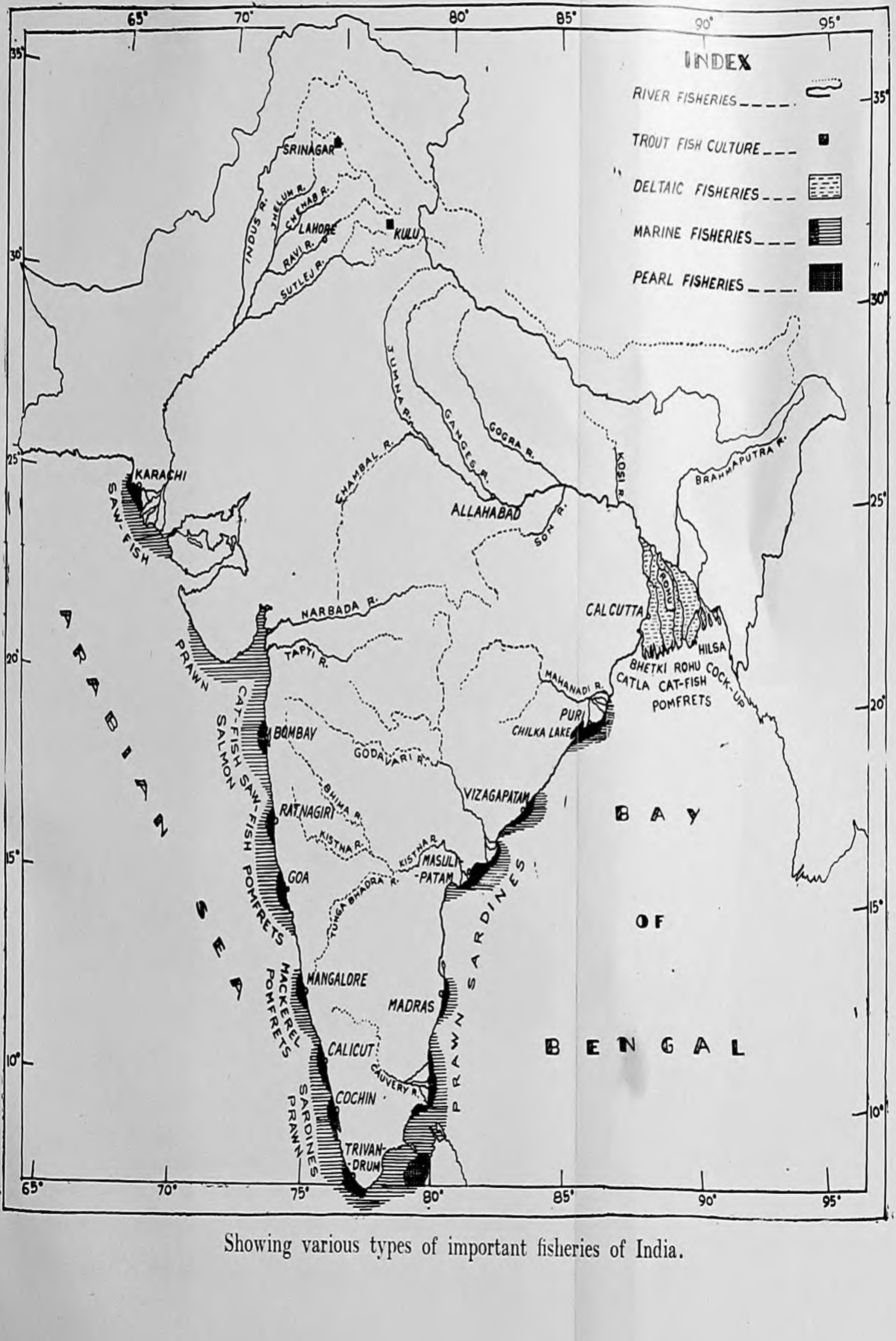
The fisheries can be classified into (1) inland and (2) marine. The former can be further classified into (a) fresh-water and (b) estuarine, while the latter can be subdivided into (i) foreshore, (ii) offshore and (iii) deep sea fisheries.

Bengal

The fisheries of Bengal, which comprise both inland and marine fisheries, are very important. The fresh-water areas include all the inland rivers, lakes (*jhils*) and tanks. The estuarine regions are found in the districts of 24 Parganas, Bakarganj and Khulna. The important varieties of fish obtained from the numerous waterways of Bengal are *hilsa*, *rohu*, and *katla*. Of all these *hilsa* fishing is carried on most extensively. Prawns and shrimps also abound.

Tank fishing is very important in those places, greatly distant from rivers, but unfortunately some tanks are so shallow that they dry up in summer. The tank fish, owing to its better quality, fetches higher price than the river fish.

Estuarine Fisheries :— The forest swamps, the islands and a host of rivers joined to each other by numerous creeks in the Sunderbans, about 5,800 square miles in area, represent the estuarine fisheries of the province. Expansion, however, is greatly impeded owing to poor transport facilities. Fishing methods also need considerable improvement. Improved rapid methods of transport in steam launches along with refrigeration will prevent a great deal of waste by putrefaction.



Showing various types of important fisheries of India.

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In Bengal 644,000 persons subsist by fishing, while 324,000 live by fish trade. A fisheries expert has been appointed by the Bengal Government to survey the present conditions of fishing industry and to devise schemes for the augmentation of supply of fish food, to organise speedier transport, better marketing arrangements, the organization of cold storage and factories for developing by-products of fish.

In conclusion it may be observed that there are immense possibilities for the development of an extensive fishing industry in the coastal regions of Bengal. The fishing should be organized on right lines for improving the crude and indigenous methods of poor and disorganised fishermen. They should use improved nets, scientific methods of fishing and preserving the fishes. They are unable to send the quality fish to suitable markets and most of their catches fetch only low prices or are only dried. Their methods are very defective as the catches are dependent on the movement of the fishes and on the currents. The modern practice in Europe, America and the Far East is that the trawlers force the fishes, irrespective of currents into their strong and big drag nets.

Orissa

Both marine and fresh-water fisheries abound in the province of Orissa. A fishing area of 30,000 square miles of the Bay of Bengal along a coast of nearly 380 miles is not at all properly developed and exploited.

The fisheries of the Chilka lake are properly exploited owing to the remarkable transport facilities

provided by the Bengal Nagpur Railway. The following figures represent the annual exports of fish from the provinces of Bihar and Orissa.

Bihar	...	53,700 maunds
Orissa	...	42,000 ,,

Madras

Madras is very well situated for sea-fishing and has a coast-line of 1,750 miles with an area of 40,000 square miles within a depth of 100 fathoms. But there being no good harbours on the east coast, this region is not properly exploited except by poor fishermen with their old-fashioned equipment. The West Coast, however, enjoys more favourable conditions. The weather is such that fishing is possible from September to April. The fishing population of the West Coast numbers about 138,294. The fish include seer, pompfret, whiting, sardines and mackerel. However, the last two are the most predominant.

Possibilities of deep sea fishing are being tested. The enterprising and bold fishermen of Ratnagiri fish beyond the 5-fathom line and return to Malpe and Mangalore with their large catches which are cured for export.

The Department of Fisheries, Madras Government has improved and devised the following:—

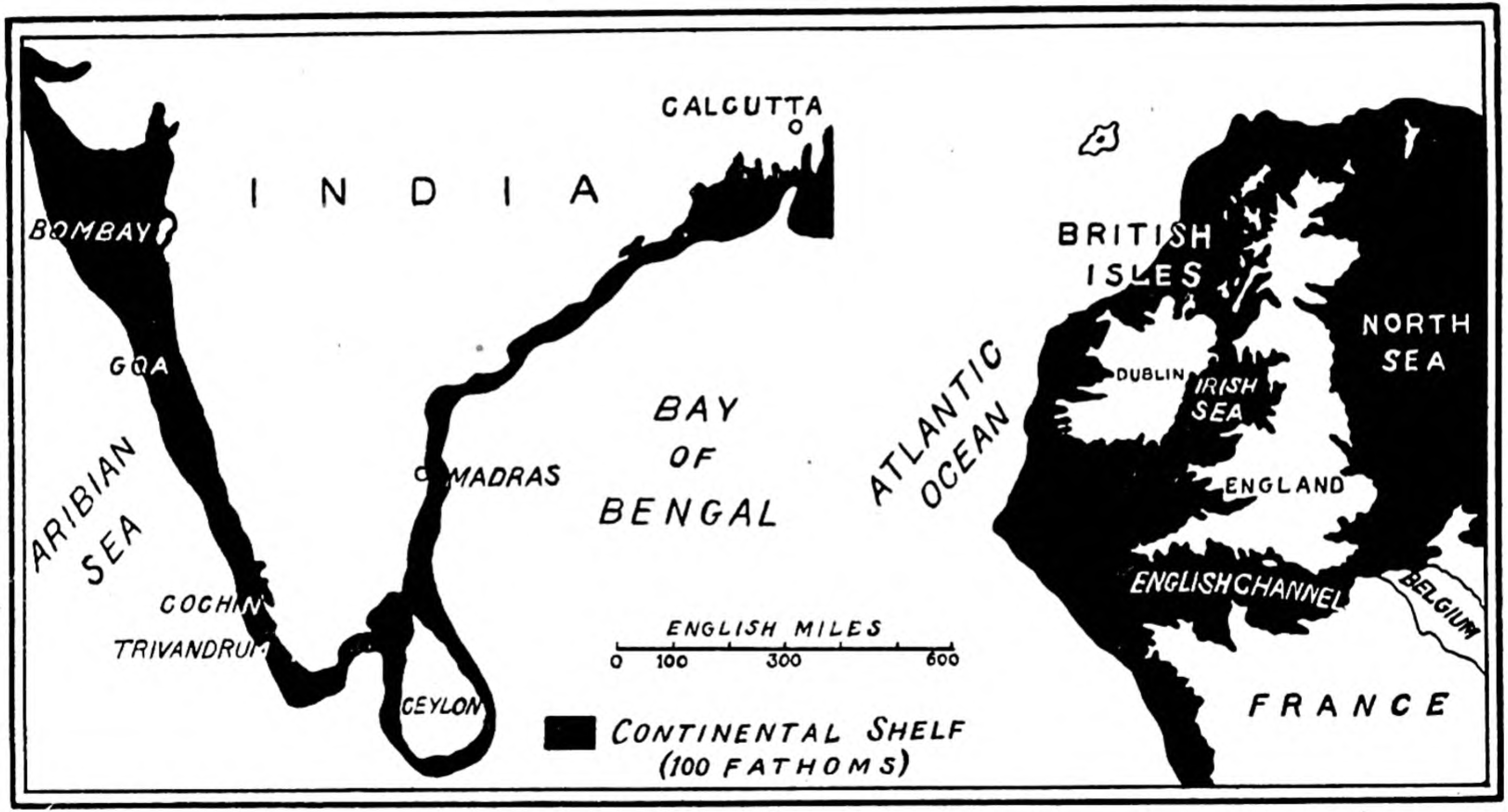
(1). Fish-oil trade.

(2). Fish-guano industry.

(3). An oyster farm.

PLALE VIII.

TO FACE PAGE 116.



Showing the continental shelf or 100-fathom line around India for marine fisheries. The continental shelf around the British Isles is also shown for purposes of comparison.

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(4). The extraction of shark liver oil with vitamin A, which is nineteen times richer than the ordinary, medicinal cod liver oil.

(5). The manufacture of isinglass, pearl buttons, shell bangles, etc.

Fish-Curing:— A considerable quantity of fish-curing is carried on at Madras. Salt is supplied duty free for purposes of fish curing. There are 100 fish-curing yards along the coast and 1,210,907 maunds of fish were cured during 1937-38.

On the lower Malabar Coast fish used to be converted into a manure by very wasteful processes. Now the Department of Fisheries has devised a process by which the oil is extracted easily and the residue used as "Fish-Guano" which is a very good manure. It is greatly in demand on the tea estates of South India and is also exported from the ports of Cochin and Calicut to Ceylon, the United Kingdom and Germany. The oil is used in candle- and soap-making.

Pearl Fisheries:— Pearl oysters are reared near Krusadai Island, Pamban with the possibility of producing cultured pearls.

Fresh-water Fisheries :—The fresh-water fisheries of this Presidency are very extensive and cover an enormous area. The most important rivers are the Godavari, the Kistna and the Cauvery, the westerly drainage flowing into the Arabian sea and the streams rising on the Nilgiris. The rivers flowing into the Bay of Bengal carry an immense volume of water during the rains, but during the drier months their waters are

largely diverted into irrigation channels, etc. But their upper reaches, particularly the deep gorges almost serve as fish sanctuaries. The rivers flowing into the Arabian sea are not much interfered by irrigation works and these perennial streams by proper stocking and conservation could be developed into important fisheries. Tanks and reservoirs, although primarily intended for irrigation purposes, also serve as important fisheries. For instance, there are the great irrigation wells in this Presidency; in the Coimbatore district alone there are at least 80,000, each many square yards in area and seldom or never dry. Fish are seldom, though occasionally grown in these waters, yet if each well were stocked with say, murrel, the minimum aggregate annual production has been estimated at 1,000 tons valued at about three lakhs of rupees. This would show that there is a great scope for the development of even fresh-water fisheries of this Presidency.

Trout culture in the Nilgiris, which were barren of fish, has proved very successful. They now abound with a large quantity of food material and provide sport and a large income.

Bombay

The coast of Bombay possesses important sea fisheries as it has a long coast-line with good harbours which can provide excellent shelter to fishing boats. It has a good fishing season for seven months and its fishermen are enterprising and ingenious. Now faster motor transport is used to bring the fish to the markets from the catching fields and for this purpose at least four

Government launches besides eight private ones are employed. Cold storage facilities have also been provided in the markets of Bombay.

Inland Fisheries :— The Government of Bombay propose to experiment on the development of inland fisheries and for this purpose they are going to try the experiments in the two tanks at Bandra which they are taking on loan from the Bandra Municipality.

Pearl-Fisheries :— In the Bombay Presidency, small pearl-fisheries exist within the harbour of Bombay. Pearl oyster fisheries are also found at Thana, 20 miles from Bombay.

Coast of Kathiawar

The coast of Cutch and Kathiawar is also visited every season by fishermen living between Surat and Bassein. Messrs Tata and Co. have established the manufacture of sardine oil and tinned fish at Ernakulam on the West Coast.

Pearl-Fisheries :— Pearl fishing is also carried on in the Gulf of Cutch. One enterprise for true pearl oysters belongs to the State of Jamnagar and the other, which is for window-pane oysters only, has been initiated by the State of Baroda.

Sind

In the province of Sind sea fishing is carried on on a large scale near Karachi. Inland fisheries, especially abound in the Indus River for the fish called *palla* and they bring a revenue of about Rs. 20,000 annually to the Government.

Pearl-fisheries are found in the harbour of Karachi.

United Provinces

The fisheries of the United Provinces are prolific and well distributed as a large number of big rivers with their tributaries flow through the province. To name only the important ones, they comprise the Ganges, Jumna, Sarda, Gogra, Rapti and Betwa. In the western part there are important canals taken out from these rivers. Almost all districts have their lakes, tanks and ponds. Thus the fisheries of this province as those of other inland provinces, comprise (a) perennial rivers : (i) montane and (ii) sub-montane, (b) canals, (c) seasonal streams, (d) natural lakes and *jhils*, (e) artificial reservoirs, (f) masonry tanks and (g) flooded fields. The important fish comprise *mahaseer*, *rohu*, *kalabans*, *katla*, *murrel*, *hilsa*, English trout and prawns.

These fisheries, though rich, yet are not adequately and properly exploited. The supply of fish is, therefore, irregular and inadequate. It may be noted that there are great possibilities of trout culture in hundreds of miles of streams in the Himalayas.

Mallahs (boatmen) of Gorakhpur and Basti export some dry fish to Nepal.

Punjab

Trout-fishing, which has been recently introduced in the hill streams of Kulu, is gaining importance. Experiments in fish culture in tanks and ponds are also being tried.

In January, 1945 the Department of Fisheries was placed in the charge of a separate Warden of Fisheries. This department is now concerned with the conservation, development, exploitation and marketing of fisheries. The revenue from fisheries in 1944-45 amounted to Rs. 1,81,394. Fish ladders have been provided at all the headworks of the canals except those of Tajewala and Sidhnai. In order to enable the fish to migrate successfully upstream, fish ladders are being improved.

It appears that the annual fish production of the Punjab has improved tremendously. In 1920 the annual production of fish in Lahore markets was 7,264 maunds which increased to 38,826 maunds in 1943-44. In 1924 there was one wholesale market in Lahore, but now there are eight wholesale markets. Attempts are being made to induce the public to undertake fish farming.

Travancore

The State has a coastline, 172 miles in length and there are 3,900 square miles of shallow-water area within the 100-fathom line, but only a distance of 5-7 miles is being exploited at present. The coast, which is surf-ridden, is deficient in harbours and during the monsoons the fury of the breakers proves a great handicap to fishing. From Cape Comorin to Trivandrum, the unsinkable Catamarans is the only possible fishing craft.

The table fish of the coast comprise pomfrets, seer fish, tunny, whiting, mackerel, etc. Shoal fisheries are of great economic importance and during favourable

seasons butter fish, ribbon fish, white bait and cat fish are so abundant that large quantities are salted and dried both for consumption in the State and for export to Ceylon and the adjoining Tamil districts. The value of these exports is Rs. 23,00,000 *per annum*. A refrigerating plant has been installed in Trivandrum for the storage of fresh fish.

The Fisheries Department commenced the manufacture of Shark liver oil in 1939 and the annual output is about 15,000 lb. which is exported to India and Ceylon.

The lake fisheries, which extend from the borders of Cochin to Trivandrum, are important. The largest lake measures 30 miles in length with a maximum breadth of 10 miles. Because of the proximity to the sea and tidal influence some varieties of fish and prawns migrate into these lakes at times. Prawn represents the most important migratory form, and the annual value of its catches is about Rs. 25,00,000, out of which dried prawn pulp is exported of the value of Rs. 15,00,000.

The value of fisheries industry to the State is estimated at Rs. 1,20,00,000 *per annum*.

Cochin

Like Travancore this is also a maritime State with a coastline, 35 miles in length. Its fisheries comprise marine, estuarine and fresh-water. The marine and estuarine fish comprise sardine, mackerel, butter fish, sole fish, sharks, rays, seers, etc. The annual production is estimated at 2,50,000 maunds. Prawn fishing in the sea and the extensive lagoons is also

important and the pre-war export trade in hard-dried prawn pulp was valued at Rs. 15,00,000. Shark liver and Ray liver oils are also being manufactured. Attempts are also being made to develop deep sea fishing.

Production

Sea-Fish :- It has been estimated that the total annual production of sea fish in India is 11.6 million maunds valued at 302.7 lakhs of rupees. Of this 71 per cent. is produced in India and Pakistan and 29 per cent. in the Indian States. The West Coast, excluding Baluchistan, and comprising a coastline of 1,150 miles, produces 66 per cent. of the total catch, while the eastern coast with a length exceeding 1,770 miles yields only the balance of one-third. On the West Coast, the South Kanara and Malabar districts are rich fisheries area and with a coastline of only 215 miles produce nearly 25 per cent. of India's output.

The foreshore of Bengal is the most productive area on the Bay of Bengal Coast. It represents a network of rivers, water courses and estuaries and although only a small portion of the marine fishery resources of Bengal have been exploited, yet a considerable quantity of fish is produced.

Fresh-water Fish :—The total estimated marketable surplus of fresh-water fish is 6.25 million maunds valued at 742.3 lakhs of rupees. Of this 94 per cent. of the available fresh-water fish is marketed in British India, while the balance is disposed of in the Indian States. Bengal naturally is the leading province in regard to the production and value of fish caught,

the actual figures being 50.1 per cent. and 58.32 per cent. respectively. Bihar comes next, Assam being a close third and the three provinces of Bengal, Bihar and Assam are responsible for about 77 per cent. of the total fresh-water fish marketed in India. It may be noted that Madras, which is the leading province in the production of sea-fish, produces only three per cent. of the fresh-water fish of India.

Seasonal Variation

With regard to seasonal variation in the production of sea-fish it may be noted that the fishing is confined only to coastal waters and is carried out only during the calm weather. Fishing season starts at the close of the south-west monsoon and peak production is obtained in October and November and from February onwards the production progressively declines. On the east coast of Madras, however, conditions are different as this part of the coast is not affected seriously by the south-west monsoon, and the production is more or less uniform throughout the year.

The fresh-water fishing commences about October, but during the summer and monsoon months the fishing is poor, but the tank fishing is at its maximum, when the water level is low. It is noteworthy that in Madras, Hyderabad-Deccan and the Central Provinces, where tanks represent the chief source of supply, largest quantities are obtained from April to July.

Imports and Exports of Fish Products

Raw fish is practically not imported into the coun-

try, but large quantities of dried fish, both salted and unsalted, wet salted and canned fish and fish products e.g., Cod liver oil and fish manure of total annual average value of Rs. 16 lakhs are imported. The value of the average annual export trade in preserved fish for the quinquennium 1935-36 to 1939-40 with Ceylon, Burma, Malaya and Hong Kong was Rs. 75 lakhs.

Conclusion

It has been already stated in the foregoing that the fisheries of India are very extensive, varied and rich, but to meet the demands of the increasing population of India they are, however, very inadequate. It is, therefore, imperative that the fisheries of India should be fully explored and properly developed.

It may be emphasised that there is a great scope for research and the application of the knowledge thus gained. In the interest of the industry it is necessary that the fishermen should be provided with suitable and efficient types of nets and boats. Cold storage facilities should be made available to them. There should be arrangements for rapid collection and transport of fish to markets. Subsidiary industries for the production of fish manure, fishmeal, fish oil, fish glue, isinglass, etc. should be certainly developed as these will help in utilising fish wastes and offal and fish not suitable for human consumption.

CHAPTER VIII

NATURAL VEGETATION AND FOREST RESOURCES

The role of the forests in furthering the economic prosperity of India is hardly realised. The forests undoubtedly have an important influence on the climate and physical conditions, including rainfall, of the country and it is rightly suggested that the rapid deforestation proceeding in the country will tend to bring about arid and desolate conditions. As a consequence, arid conditions are spreading to the western districts of the United Provinces. As noted already in chapter XVIII of Part I of this work, forests can check soil erosion, floods, lowering of the ground water level, desiccation or spread of desertic conditions. The forests also supply timber, firewood and many minor forest products. But the forests of India, excluding the Indian States, occupy only 14 per cent. of its area, of which 9 per cent. is merchantable. Out of this area, 100,000 square miles are under Government reserved forests. According to Sir C.G. Trevor "foresting in India was concerned with every type of vegetation from the tropical rain forest to temperate coniferous forests of the Himalayas". The province of Assam enjoying a heavy rainfall, naturally has the most extensive forests occupying about 40 per cent. of its total area. The area of different provinces along with their total forest areas, percentage of the forest to the total area (See Fig. 18) and the quantity of timber and fuel produced along with the value of the minor forest produce (See Fig. 19) are tabulated below :–

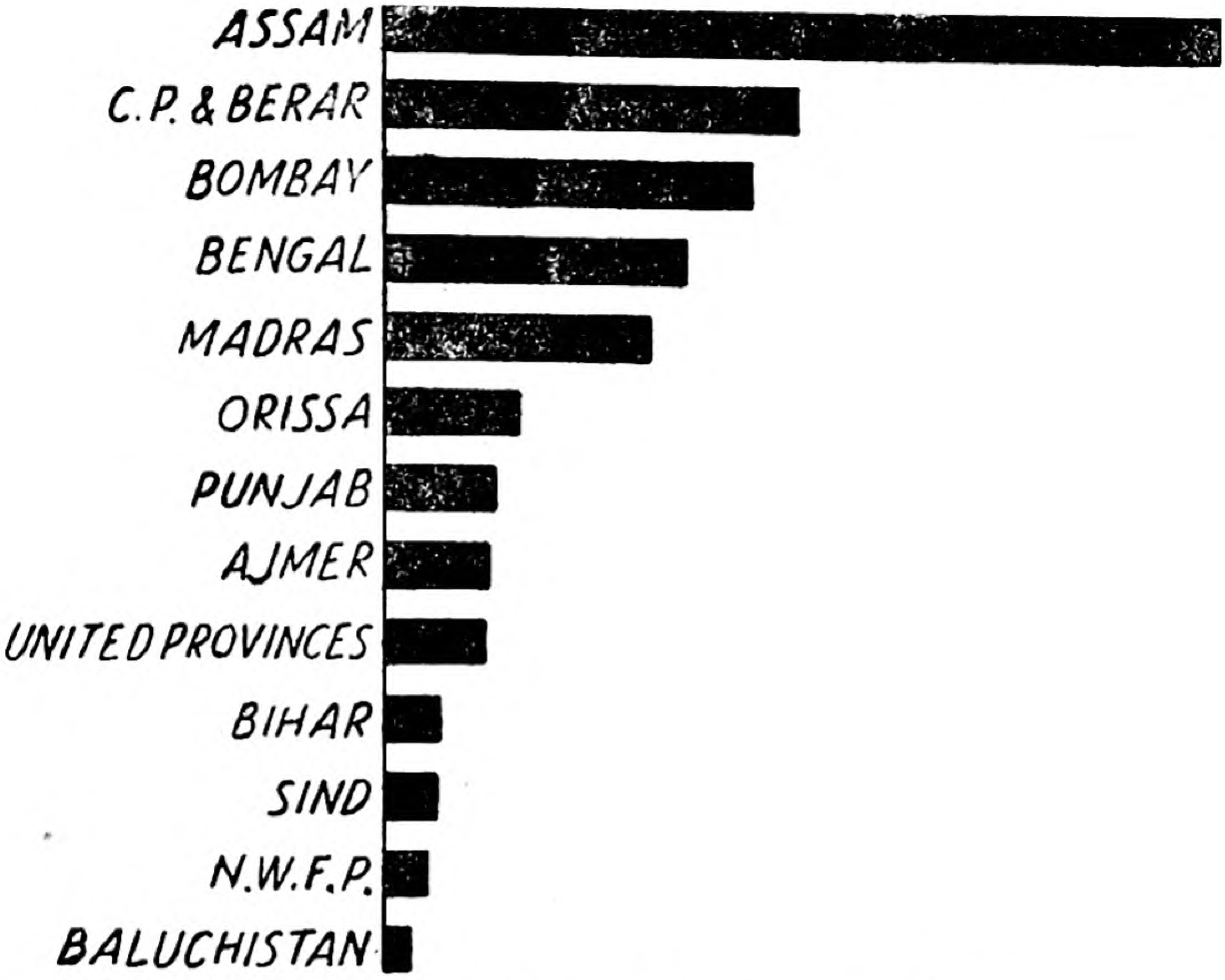

Fig. 18—Showing percentage area under forests in different Provinces.

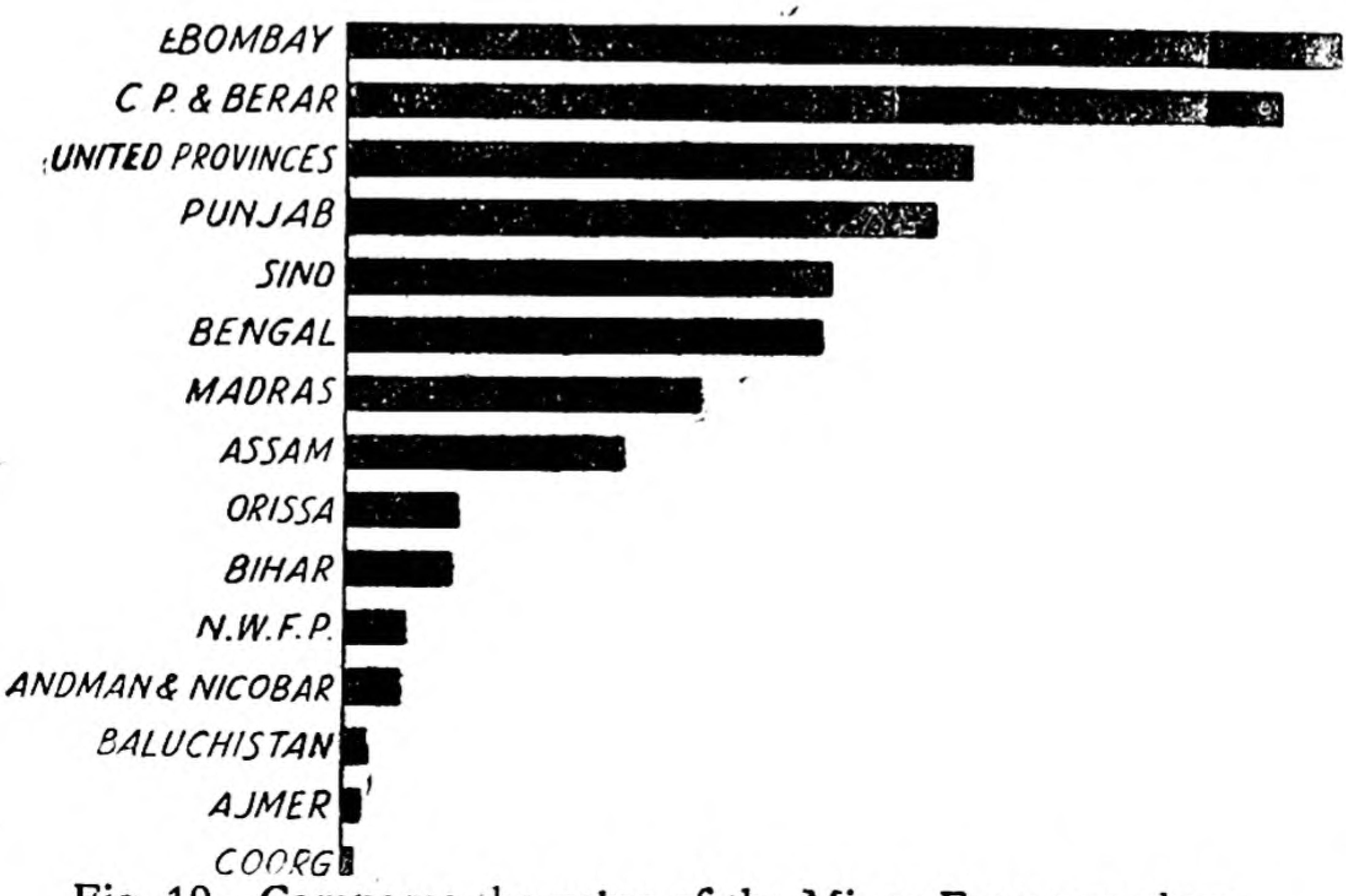

Fig. 19—Compares the value of the Minor Forest produce of different Provinces.

Province	Area of the Province in square miles	Total Forest Area in square miles	Percentage of forest area	Timber and Fuel in cubic feet	Minor Forest produce in Rupees
Madras	125,163	15,245	12.2	17,866,000	2,10,972
Bombay	76,127	12,998	17.1	49,814,000	29,46,440
Sind	47,138	1,157	2.5	24,021,000	1,24,113
Bengal	76,960	10,803	14.0	23,905,000	4,18,840
U. P.	106,014	5,251	4.9	31,389,000	12,92,000
Punjab	93,315	4,842	5.1	29,817,000	17,05,815
Bihar	69,257	1,786	2.6	5,399,000	1,84,360
Orissa	32,179	1,985	6.2	5,489,000	1,90,770
C. P.	98,445	19,413	19.7	47,400,000	20,21,477
Assam	55,445	21,393	38.6	14,122,000	5,39,150
N.W.F.P.	13,184	282	2.1	3,450,000	52,835
Baluchistan	46,974	813	1.7	1,053,000	5,625
Ajmer-Merwara	2,767	142	5.1	613,177	60,3735
Coorg	1,593	839	52.7	566,751	3,27,633
Andaman and Nicobar	2,508	2,189	87.0	3,371,000	8,151
Total	1,106,310	241,743	23.6	375,606,027	1,09,87,468

Classification of Forests

For administrative purposes the forests are classified into (1) Reserved and (2) Protected. But Government forests may also be classified into :–

(1) Forests, which are required for climatic and physical grounds, i. e., for the prevention of floods, soil erosion, desiccation and extension of arid or semi-arid conditions. Such forests are styled as Protection Forests. This problem has been discussed in Chapter XVIII of this work, *India*, Part I—*Physical Basis of Geography of India*.

(2) Timber forests which are principally meant for timber supply and revenue.

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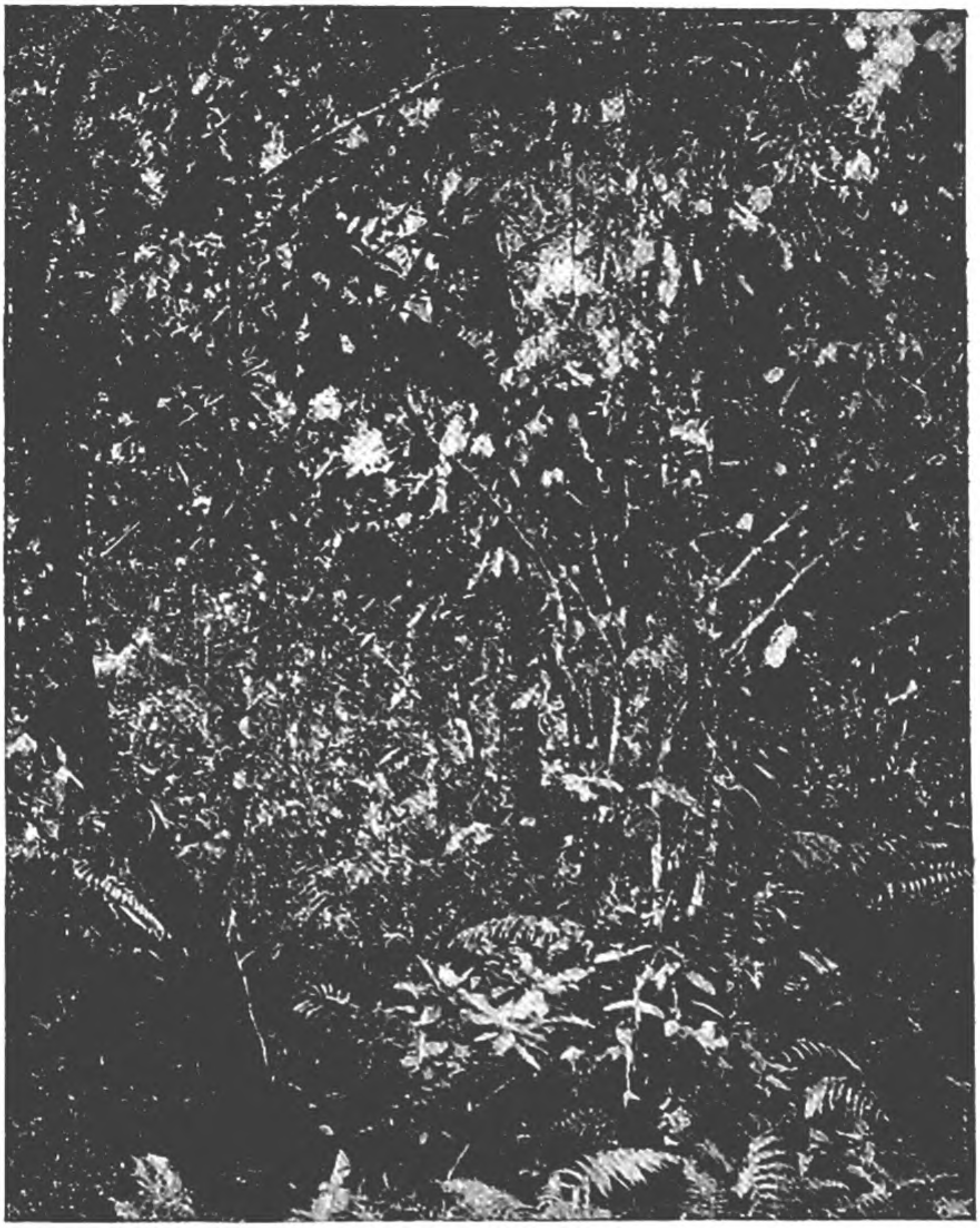

Showing a typical equatorial evergreen forest, Travancore.

(3) Minor forests which are intended to supply local requirements.

(4) Pasture forests which serve as grazing grounds for animals.

Natural Vegetation

It may be stated at the outset that the vegetation of a given locality depends on the climate including temperature and rainfall, the soil and the historical factor. Of course topography and altitude determine climate. Aspect plays an important part in the nature of vegetation as shown by the vegetation of the southern and the northern slopes of the Himalayas.

It is noteworthy that India experiences climates, varying from the equatorial to the Alpine in character and possesses almost all types of forests (See Fig. 20). Hot, wet equatorial forests occur on the West Coast. The Central Provinces and the adjoining regions are covered with deciduous forests, while the Himalayas are covered with the swampy jungles of the Terai in the foot-hills and coniferous evergreen forests on the higher slopes, while the Alpine vegetation occurs below the limits of perpetual snow. The desertic vegetation is found in Sind, Western Rajputana, etc.

Hot Wet Evergreen Forests:—In the luxuriance of vegetation these forests are almost similar to the Equatorial forests of the Amazon and the Congo Basins and there is a layering of vegetation. They consist of several trees and the highest sometimes attain a height of about 150 feet, while the intermediate trees, which

have to struggle for the sun, are crowded together. Other vegetation comprises a prolific growth of climbers and the trees are covered with epiphytes. Besides

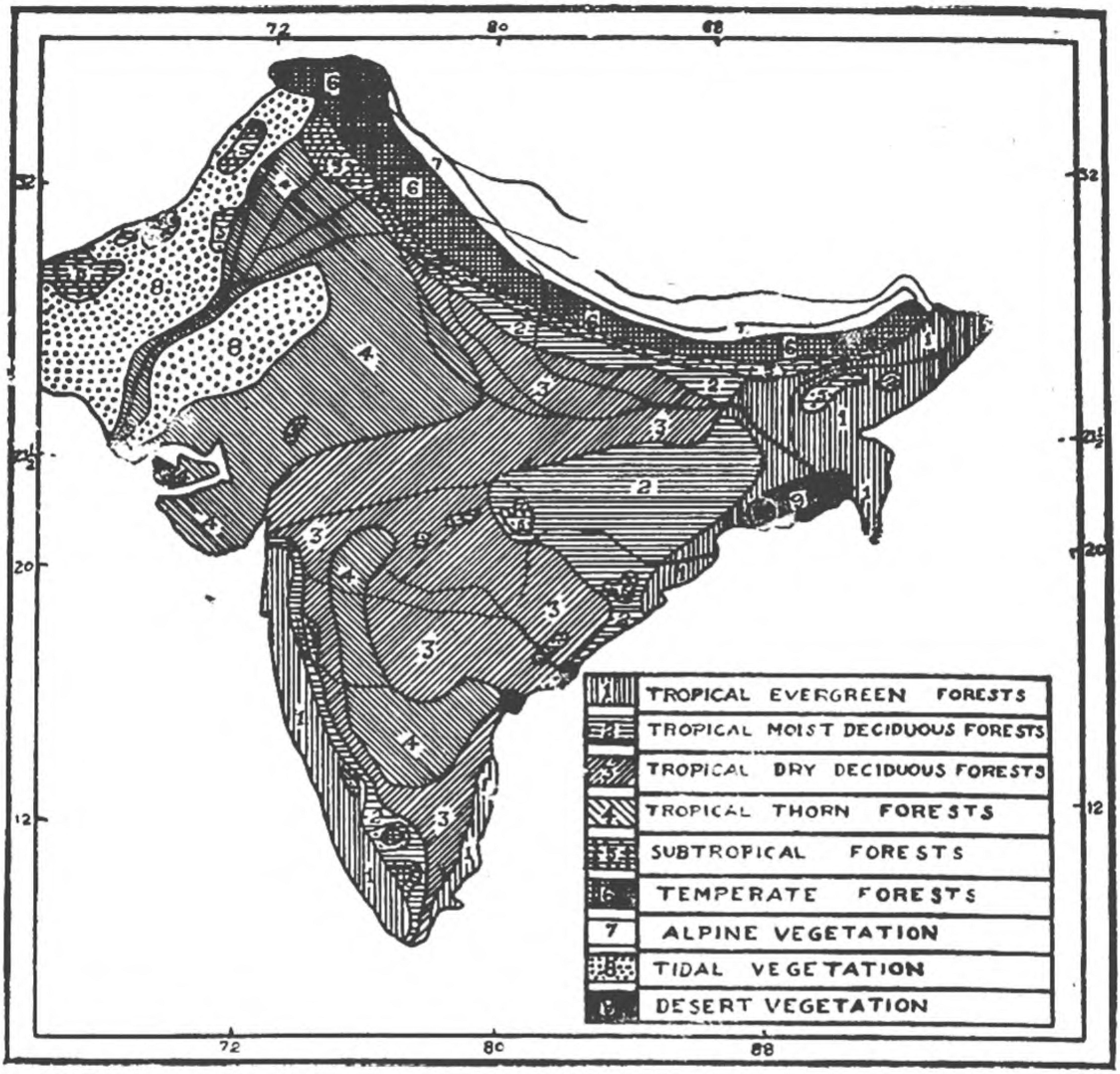

Fig. 20—Showing Natural Vegetation of India
(after Champion).

there is a very dense undergrowth of shrubs and these along with climbers make these forests sometimes impenetrable. These forests occur in regions of heavy rainfall and arė, therefore, also known as Rain Forests. They are found on the West Coast extending from North Kanara to the south. It may be observed that large

Evergreen Rain Forest with ephiphytic ferns, etc., Wynaad Division, Madras. (*Photo: M. V. Laurie*).

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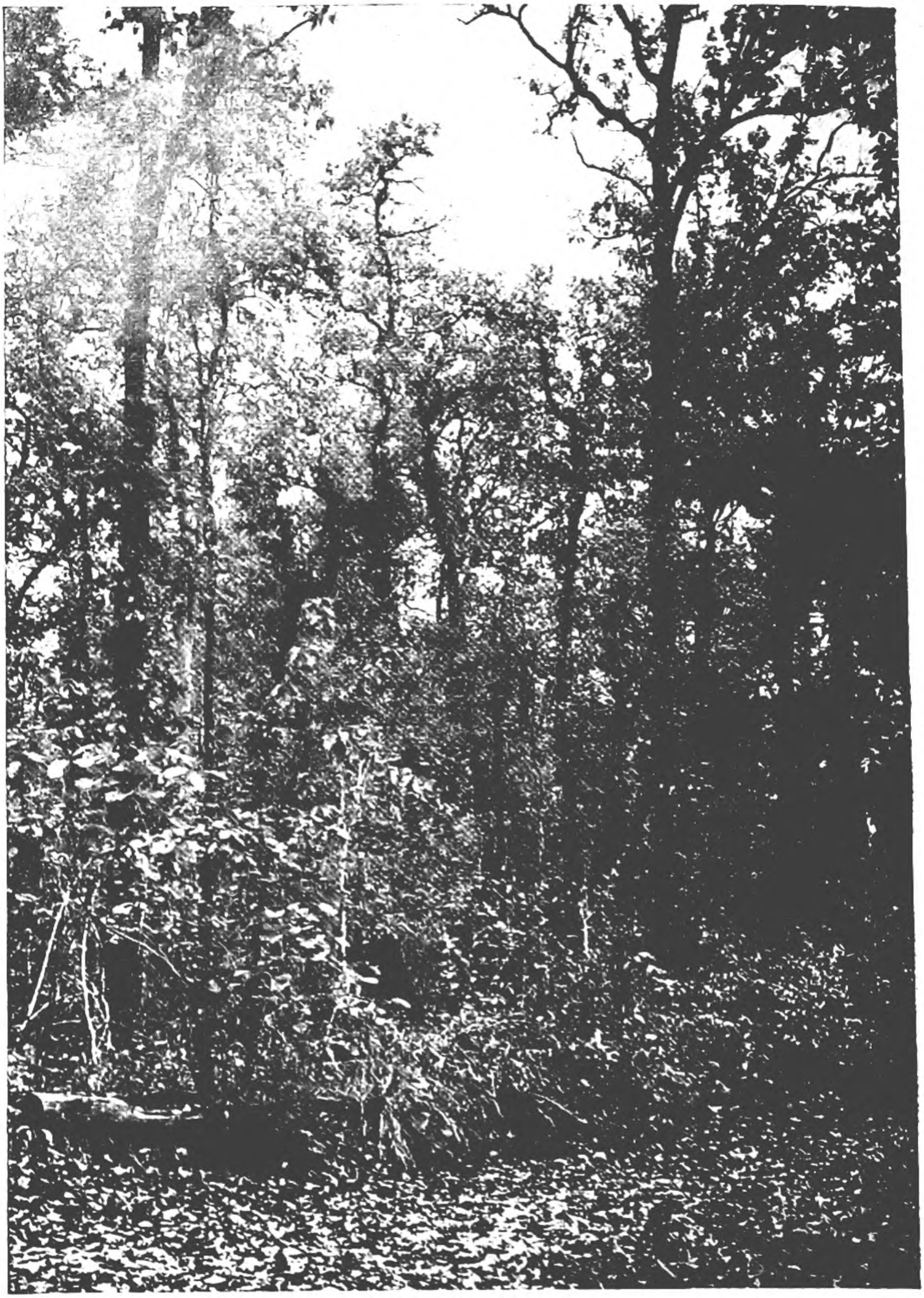


Typical moist deciduous forest (*Cleistanthus collinus* predominant), Raipur Division, C. P. (*Photo*: *K. P. Sagreiya*).

tracts of these forests have been cleared by shifting hill-cultivation or have been replaced by rubber, spices or betel plantations. The evergreen trees include the following species : *Hopea parviflora*, Gurjan (*Diptero-carpus indicus*), Poon (*Colophyllum tomentosum*), mango (*Mangifera indica*).

Temperate Evergreen Forests:—A mention may also be made of the interesting and specialised flora of the hills of the Nilgiris, Annamalai, Palni, Shevaroy, etc. These forests commence about an elevation of 5,000 feet above sea level and are locally known as *Sholas*. It may be noted that these forests enjoy the benefit of both the monsoons affecting South India. On the higher slopes these forests consist of evergreen trees of small size with a rich undergrowth, while on the lower slopes they merge into tropical evergreen forest. The important species of the temperate forests include Pila champa (*Michelia nilagirica*), *Enrya japonica*, *Terns-troemia japonica*, etc.

Deciduous Forests:—These forests occur in the Central Provinces, parts of the Deccan, the Gangetic plain and occupy considerable areas in the Sub-Hima-layas. The mixed deciduous forests are also known by the name of monsoon forests. They chiefly comprise deciduous forests which shed their leaves during the hot, dry season. They comprise the important Teak and Sal forests of India and produce some of the most important timbers of India, e. g., Teak (*Tectona grandis*), Sal (*Shorea robusta*), Sandalwood (*Santalum album*), rosewood (*Dalbergia latifolia*), ebony (*Diospyros* spp.),

ironwood, etc. These forests are further classified into the following four sub-types :—

(1) Teak forests consisting almost entirely of teak.

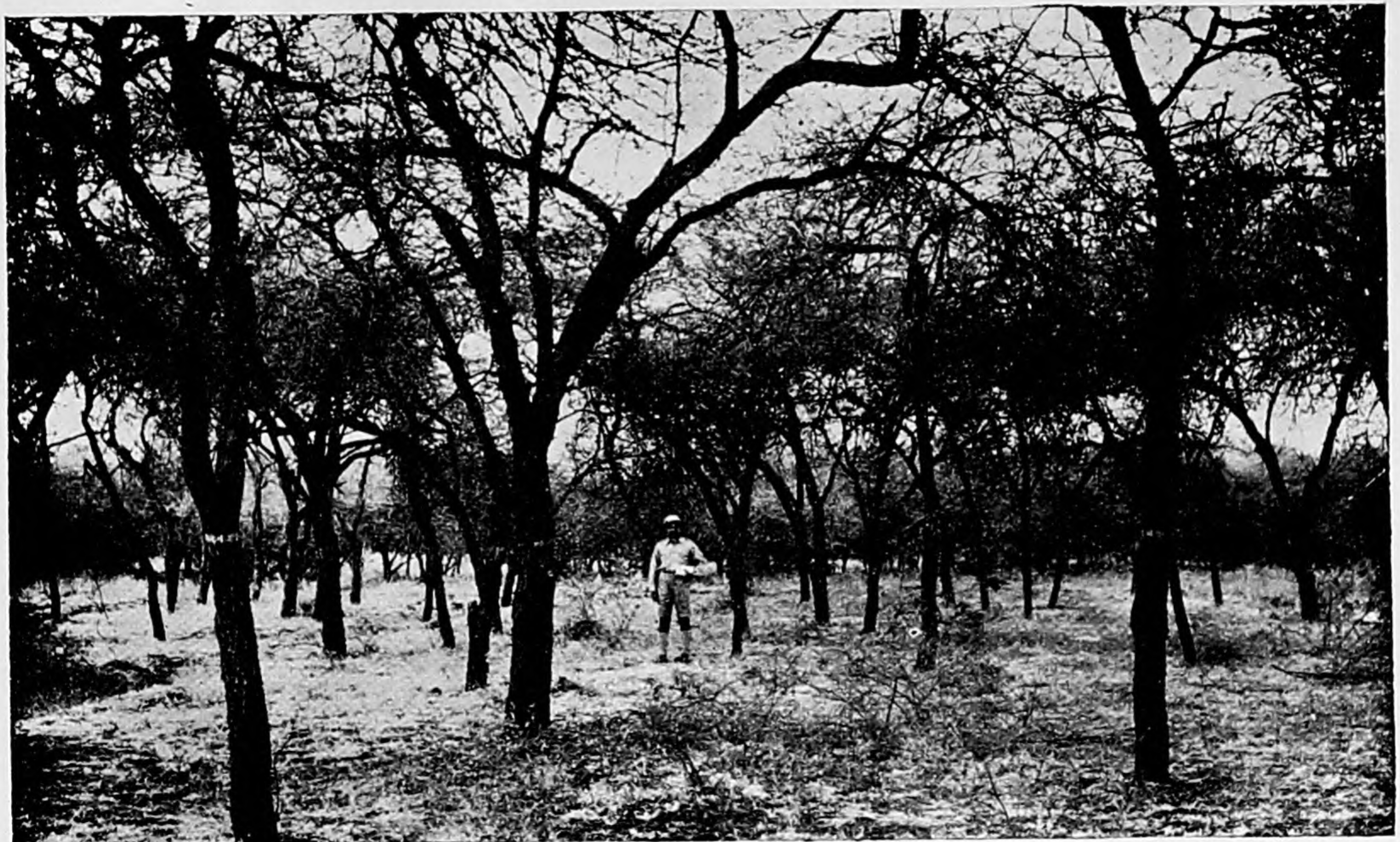
(2) Sal forests composed chiefly of Sal trees.

(3) Mixed forests consisting of Teak mixed with Sal, bamboo, etc.

(4) Bamboo forests.

Dry Deciduous forests:—These forests occur characteristically in the Northern Punjab, Sind and the adjoining regions, having a rainfall of less than 30 inches, while in most places it is below 20 inches. In the elevated *doab*, between the Jhelum and the Indus, the predominant species are Phulai (Pb.) (*Acacia modesta*), and olive (*Olea cuspidata*). Besides there is tree growth along the rivers which overflow their channels during rains where the ground is covered with Babul (*Acacia arabica*), *Prosopis spicigera* and *Populus cuphiatica*. With the extension of irrigation the important species are Babul (*Acacia arabica*), kokko (*Albizzia lebbek*), and Sissoo or Shisham (*Dalbergia Sissoo*). These forests pass on to Acacia scrubland and desertic vegetation in still drier regions.

Arid or Semi-arid Vegetation:–This type of vegetation occurs in parts of Sind, Rajputana, Baluchistan and the Southern Punjab where the rainfall is less than 20 inches. It is remarkable that vegetation diminishes towards the desert region and disappears almost in the arid parts. Tree vegetation, e. g., Babul (*Acacia arabica*) occurs only along the rivers as a result of their periodical inundation in the form of riverain forests, e.g., along the Indus in Sind.



Acacia arabica forest, near Akola, Berar. (*Photo: M. V. Laurie*).

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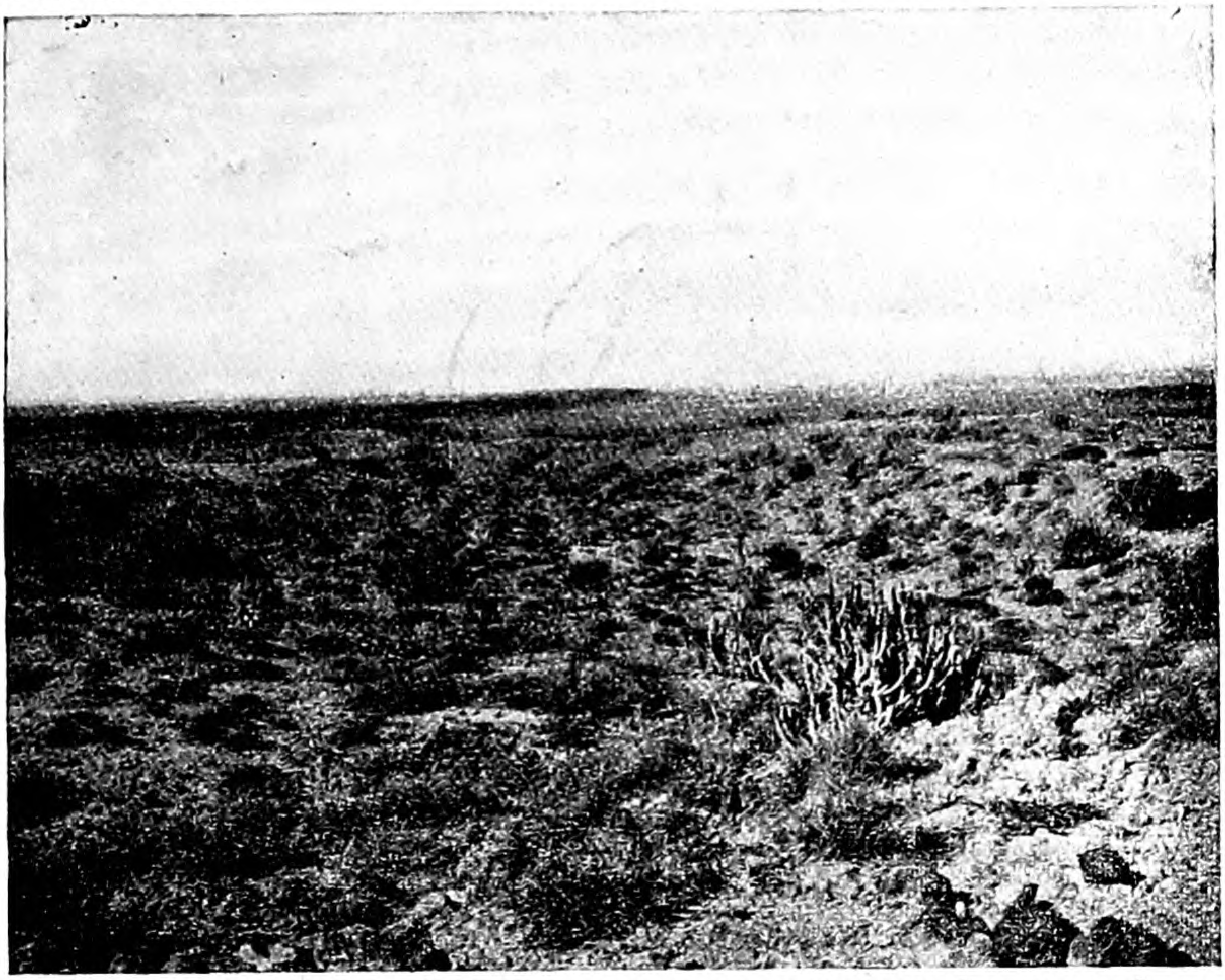
PLATE XIII. To face page 132.



A typical view of desertic vegetation in Sind (By Courtesy of *the Bombay Natural History Society*)

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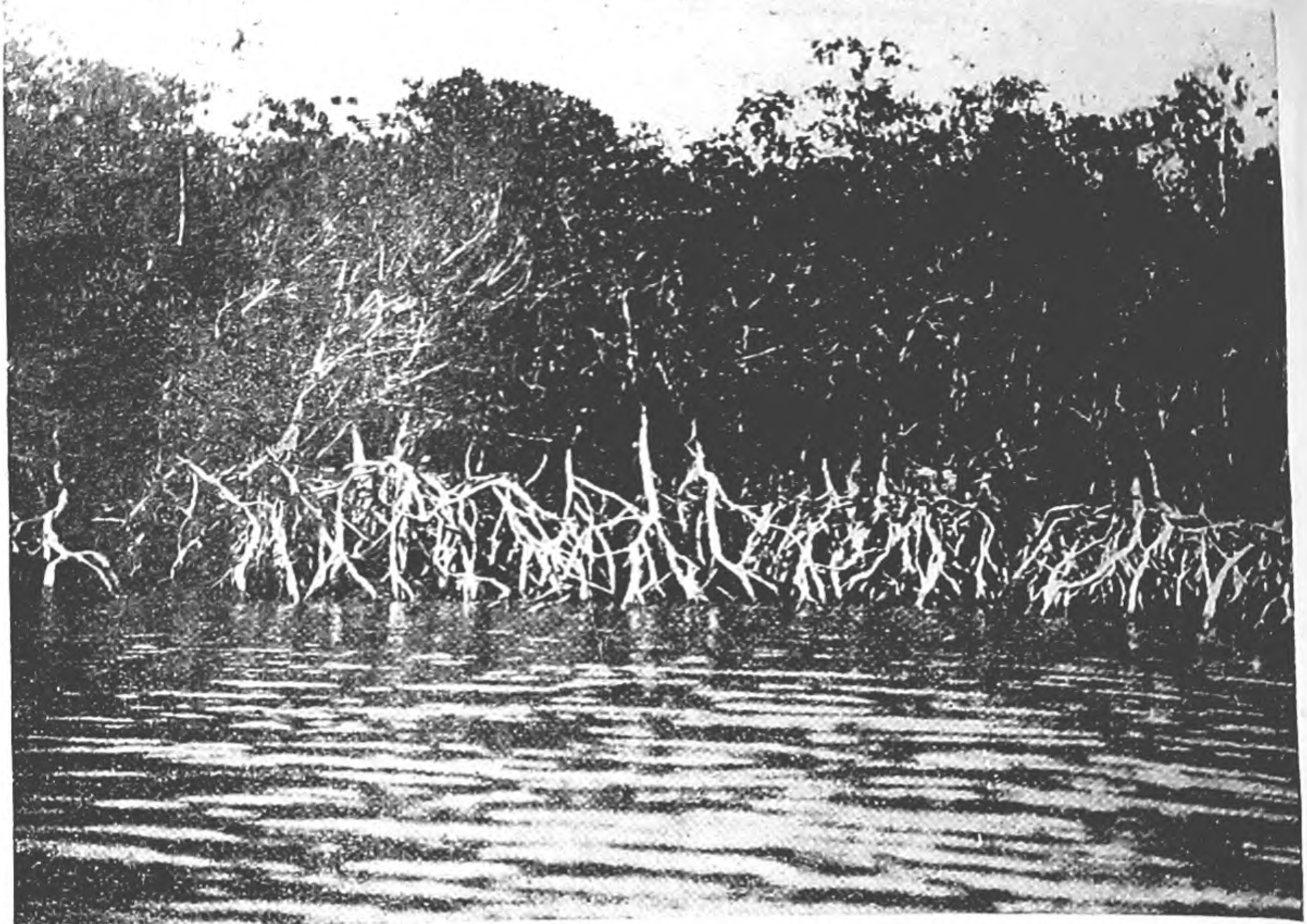
PLATE XIV. TO FACE PAGE 133.



Mangrove or the Littoral Forest in the Delta of the Ganges, South Sunderbans showing the conditions at high tide near the sea. (By courtesy of the *Bombay Natural History Society*).

PLATE XV. TO FACE PAGE 133.

The Sunderbans at Low tide. A water channel gives access to the interior of the jungle. (By courtesy of *the Bombay Natural History Society*).

Mangrove or the Littoral Forests:—These forests occur on the coastal regions, e.g., on the east and west coast and the tidal swamps of the Gangetic delta. The most characteristic species belong to the mangrove family of *Rhizophorae* in which Bhara (Beng.) (*Rhizophora mucronata*) is the predominant species. This region is somewhat unhealthy as it is largely composed of soft muds exposed to the action of tides. Under these practically water-logged conditions vegetation begins to decay and stink. The jungles are infested with tigers, poisonous snakes, malarial mosquitos, etc.

A reference may also be made to the forests of the Sunderbans (also written as Sundriban). They occupy largely the delta of the Ganges and the Brahmaputra composed of alluvium of recent origin and the land is gradually gaining on the Bay of Bengal. The chief species seen in this tract include Sundri (Beng.)(*Heritiera Fomes*), Keowra (Beng.) (*Sonneratia apetala*), *Cerapa moluccensis*. *Amur* (Beng.) (*Amoora cucallata*) and *Avicennia officinalis*.

The Himalayas

The natural vegetation of the Himalayas is indeed very interesting. Based on climate, including precipitation, the Himalayas may be classified into two main regions:—

(1) The Western Himalayan region.

(2) The Eastern Himalayan region.

A concise account of the vegetation of these regions is given below:-

(1) *The Western Himalayan Region:–* It comprises the Himalayan range including the Sub-Himalayan tract from Kumaun to Chitral. The rainfall of this region varies from 40 to 80 inches, which in places may be 100 inches or even more. But in the valleys and towards the north-west the climate is dry. According to elevation this region can be subdivided into three zones.

(i) The sub-montane zone and the outer hills extend to an elevation of about 5,000 feet above sea level. This zone almost forms a continuous belt of Sal (*Shorea robusta*). This belt in places is interrupted by savanna with scattered trees, the chief being Dhak (*Bhutea frondosa*) and Semul (*Bombax malabaricum*). Other types of forests found in this region are:—

(a) Riverain forests of Khair (*Acacia Catechu*) and Shisham (*Dalbergia Sissoo*).

(b) Swamp forests of jaman (*Eugenia jambolana*), Siris (*Albizzia procera*) and Gular (*Ficus glomerata*).

(c) Dry thorn forests of Ber (*Zizyphus Jujuba*) and allied species.

(d) The mixed deciduous forests with several species of *Terminalia*, Semul (*Bombax malabaricum*), Amla (*Phyllanthus Emblica*), Jhingan (*Odina wodier*) and Kuthan (*Hymenodictyon excelsum*). Towards the upper limit Chir (*Pinus longifolia*) appears and forms a belt.

(ii) The temperate zone of mixed coniferous forests which extend from 5,000 feet to 11,000 or 12,000 feet above sea level. As the name indicates they represent large forests of coniferous with broad-leaved trees. On

Fig. 1—Pine forest near the 16th mile from Kathgodam *en route* to Nainital (see page 139). (*Photo: H. L. Chhibber*)

Fig. 2—Showing the *Banj* oaks (Quercus) at Lansdowne. Note their distorted stems. They do not yield good timber, but serve as fuel. (*Photo: H. L. Chhibber*).

PLATE XVII. To FACE PAGE 135.

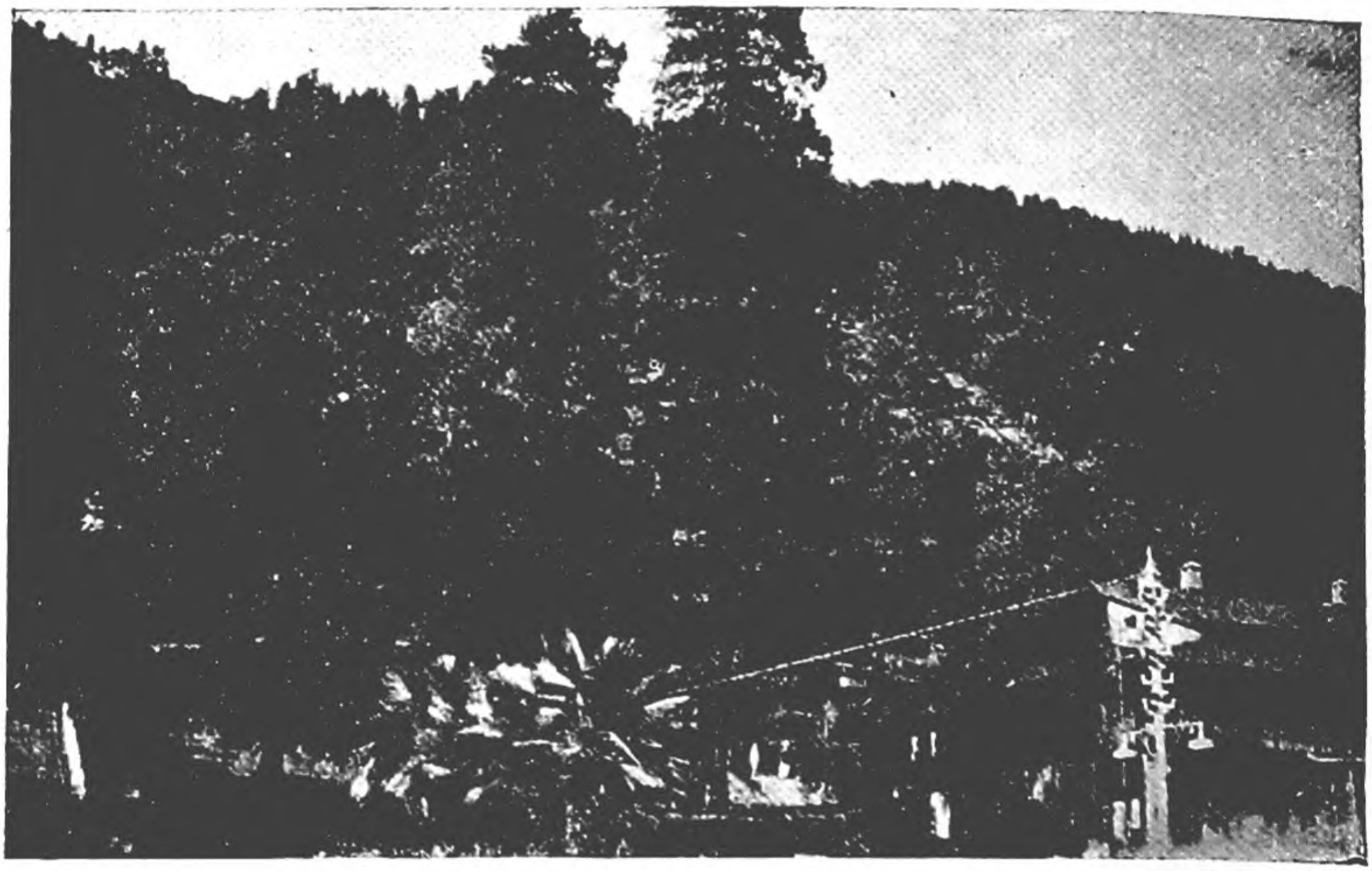


Fig. 1—Coniferous vegetation at Naini Tal with the slopes of China Hill in the background. (*Photo: H. L. Chhibber*).

lower elevations Chir (*Pinus longifolia*) is the predominant species, while the higher slopes are overgrown by Deodar (*Cedrus deodara*) and blue pine (*Pinus excelsa*). Between 8,000 to 11,000 feet Silver fir (*Abies Pindrow*) and spruce (*Picea morinda*) form large forests. The cypress (*Cupressus torulosa*) has local importance only.

The broad-leaved trees include species of oaks of which *Quercus incana* and *Quercus Dilbata* are the most important. Other trees comprise poplar (*Populus ciliata*), alder (*Alnus nepalensis*), elm (*Ulmus Wallichiana*), birch (B*otula alnoides*), etc.

(iii) The Alpine vegetation extends from 11,000–12,000 to an elevation of 15,000 feet above sea level or more, the predominant trees being the Silver fir, the Silver birch and Juniper. Three species of rhododendron occur in this zone, but they are far more numerous in the Eastern Himalayas.

These forests are succeeded by an Alpine scrub which consists of dwarf rhododendrons, Junipers with patches of grassland which form excellent grazing grounds in summer.

(2) *The Eastern Himalayan Region* :—This region, which is bounded by Nepal on its west, Tibet on the north and Assam and Bengal on the south is considerably more humid and extends from Sikkim eastwards. It is also divisible into three zones.

(i) The tropical forests extend up to about 5,000 feet and comprise the following types.

(a) Riverain forests.

(b) Sal forests.

(c) Moist savanna forests with stretches of tall savanna grasses, the commonest species being *Saccharum procerum*, with scattered species of white Siris (*Albizzia procera*), Semul (*Bombax malabaricum*), *etc*.

(d) Mixed deciduous forests with several species of *Terminalia*, Lendi (*Lagerstroemia parviflora*), Semul (*Bombax malabaricum*) and Kadam (*Anthocephalus cadamba*).

(e) Evergreen forests include a host of species, e.g., Chilauni (*Schima Wallichii*), Dillenia (*Dillenia indica*), Amoora, Cinnamon, etc.

(ii) The forests of the temperate zone of the Eastern Himalayan region enjoying much more humid climate can be divided into two zones:–

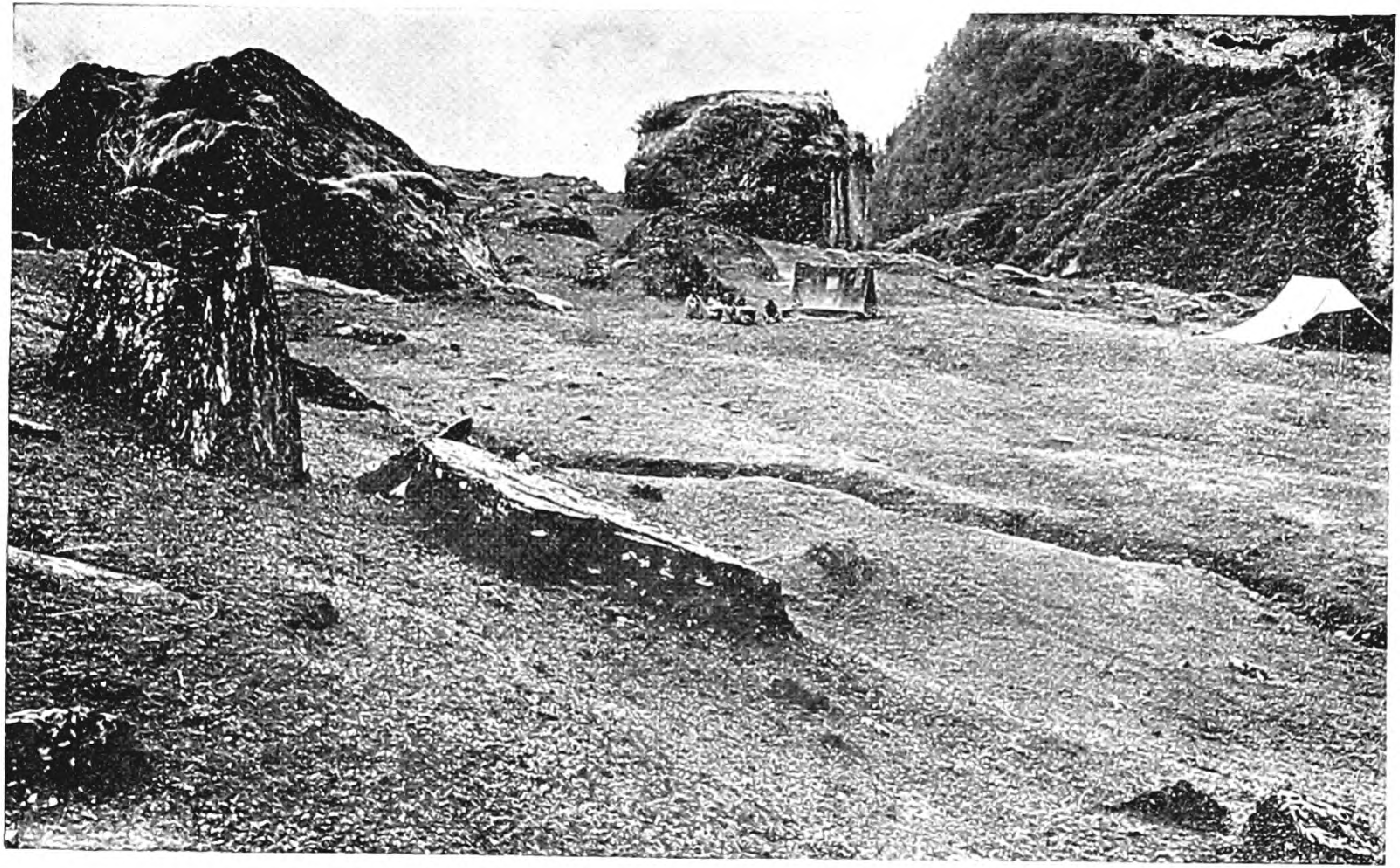
(a) The lower zone of deciduous forests which contain a number of species of broad-leaved trees comprising oaks, laurels, maples, birch, alder, etc.

(b) The upper zone, which occurs chiefly above 9,000 feet, consists largely of coniferous forests with species of *Abies Webbiana* (a variety of Silver fir), *Larix Griffithi*, willow, junipers and numerous rhododendrons.

(iii) The Alpine vegetation, which succeeds coniferous forests, extends from 12,000 to 19,000 feet. In this region rhododendrons are very prolific, while junipers also occur.

Forest Products

The products of these forests can be divided into (1) major and (2) minor.



High Level fir (*Abies Webbiana*) and Rhododendron forest with Alpine pasture, 11,000 feet above sea level, Sunderdhunga, West Almora Division, U. P. (*Photo: H. G. Champion*)

Borrower's No.	Issue Date	Borrower's No.	Issue Date

The major products include timber for railway sleepers, scantlings, etc. and firewood. In normal years the output of timber and firewood from forests under the control of the Forest Department is about 6 million tons. Including the private forests the above figure may be increased by perhaps 50 per cent.

Important Commercial Timbers of India

Among the timbers, which are used for commercial purposes, the following are the most important.

Sal (*Shorea robusta*):—The Sal forests, as noted above, occur chiefly in the United Provinces, the Central Provinces, Chota Nagpur and Orissa. The Sal is a large gregarious tree which extends almost from Kangra in the Punjab to the Nowgong district of Assam. It also occurs in Central India, the Central Provinces, Bihar and Orissa. The Sal wood is used largely for making railway sleepers and fortunately the Sal-producing regions are well-served by the railways. The Sal wood is brown in colour and is very hard and durable. It is somewhat coarse-grained ; as a result it takes long in seasoning.

The Sal forests of the U. P. cover an area of about 3,000 square miles, of which about a third is valuable. The Sal forests of the U. P. are divided into three types :—

(i) The hill forests.

(ii) The Bhabar forests.

(iii) The Terai and the Plain forests.

The Bhabar area yields the best Sal.

Teak (*Tectona grandis*) :—Teak wood is very valuable

because apart from its durability it takes a fine polish. Usually good furniture is made from teak. India possesses only small forests of teak mainly in Central India, the Central Provinces, the Western Ghats and the Nilgiris. As noted already, Teak trees occur either alone or mixed with other species and its northern limit is marked by the Narbada and the Mahanadi rivers, but occasionally it may occur to the north of this line, e.g., in Jhansi and Banda in the United Provinces. The important localities, where the most important forests occur, are: (1) the Chanda district in the Central Provinces, (2) North Kanara, (3) Wynaad, (4) the Annamalai hills, (5) Travancore State, (6) South Arcot and Mysore. There is small export of Teak from the Western Ghats.

Shisham (*Dalbergia Sissoo*):—This is a large deciduous tree and forms a very hard, close-grained wood. It grows in the Sub-Himalayan tract and also in the Himalayan valleys up to an altitude of 3,000 feet above sea level and it extends from the Indus to Assam. It often has a gregarious growth along the rivers and streams of the plains. It is noteworthy that the wood is very durable. It seasons well and does not warp or split. This wood is in great demand for all purposes, where elasticity and strength are in good demand. It is extensively used for making carriages, carts, agricultural implements, and particularly for making furniture. For carving and as a furniture wood it remains unsurpassed and it is in great demand for these purposes, particularly in Northern India. The wood carvings of Saharanpur and Simla are indeed celebrated,

It also makes a good firewood ; good pieces almost burn like coal. It produces excellent charcoal.

Chir (*Pinus longifolia*):--It is a large, long-leaved pine tree, which grows in the Outer Himalaya and the Siwalik Range at altitudes varying from 1,500 to 7,500 feet above sea level. It extends from the west in Kashmir to the east in Bhutan. It forms pure forests of great extent, wherever it is found in the Western Himalaya. For example, the forests of the Tons Valley, the most important tributary of the Jumna, occupy 100 square miles in extent. Similarly, large forests also occur in the Kumaun Himalayas, Nepal, the Punjab and the North-West Frontier Province. The working area of this pine is about 3,000 square miles, which is somewhat equally divided between the Punjab and the United Provinces. The timber of this pine is in great demand. It may be noted that the trees are situated in convenient positions and are easy of reproduction and extraction. The wood, which is light reddish brown and is moderately hard, floats fairly well and is used for construction purposes. It is also used for making boats and tea chests, etc. It is also the chief tree tapped for resin and yields a greater amount of resin than the Blue pine. A tree may yield as much as 12 lbs. of resin. The tapping of the tree for resin does not injure the timber, but is rather said to improve the quality. The resin yields colophany, which is used in the manufacture of soap, while the turpentine is employed in a number of industries. It also yields tar, which is made into pitch, for sale in the plains.

Blue Pine:—The Blue Pine (*Pinus excelsa*) is a large evergreen tree with a height varying from 100 to 120 or even 150 feet with a girth of 6-10 feet or even more. The wood is moderately hard. It grows in the temperate Himalayas from an altitude of 6,000 to 12,500 feet above the sea-level. It occurs either gregarious or mixed with other trees like Deodar. At high levels it is found mixed with the birch and Silver fir ; at low levels it is mixed up with long-leaved pine.

The Blue pine yields good timber which is superior to that of the long-leaved pine. It is next in quality to Deodar. It is mainly employed for construction purposes, and Kashmir and the Punjab largely export it to the plains. It makes good railway sleepers. It is stated that for making planks, doors, windows and furniture it is better than Deodar. It is employed for making tea boxes in Kangra and Kulu. It yields an excellent resin, and the turpentine and colophany produced are of better quality.

Deodar:—This timber (*Cedrus Libani* or *Cedrus deodara*) is a very large evergreen tree and yields a moderately hard wood which has a strong oily odour. It grows in the Western Himalayas most commonly at altitudes varying from 6,000 to 8,000 feet above sea level. It may be noted that Deodar is the chief valuable and important timber tree of Northern India. It has a gregarious habit and forms fine forests in several parts of the Himalayas, e. g., in the valleys of the Tons, the Jumna, the Bhagirathi and also in the valleys of the Punjab and Kashmir. Very stately trees of Deodar with heights, generally from 90-120 feet, are to be

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Silver fir (*Abies Pindrow*) at edge of Mundhali Thatch, Chakrata Division, U. P.

observed sometimes with a girth of 30 feet or even more. The Deodar prefers to grow on gneiss or granite or even on limestone. Two well-marked varieties can be recognised in forests, the one with dark green and the other with a silvery foliage.

The timber of Deodar, as stated above, is the chief timber of Northern India and is very largely used in the making of sleepers for various railways of Northern India. It is also greatly employed for construction as well as for bridge work. The timber is cut down into logs and sleepers high within the Himalayas, which are then transported by sledge roads or wire tramways to the rivers where they are floated down to the markets.

Silver Fir (Abies):—There are two Indian species, but there is some controversy about them. However, the more important of the two Silver firs is *Abies Pindnow*. It is a lofty evergreen tree measuring as much as 200 feet or even more with girths of about 20 to 25 feet, and the wood is white and soft It is known to occur from Chitral to Nepal at altitude of 7,000 to 9,000 feet. It generally occurs associated with the spruce, moru oak, sometimes with Deodar and blue pine. It is suitable for match industry and for making paper pulp. It can be used for making tea boxes, packing cases and planking. Unfortunately it becomes quickly waterlogged.

The Himalayan Spruce:–This tree, *Picea morinda*, is a large and lofty evergreen tree. It yields a white wood

which is soft to moderately hard. It grows in the Himalayas at an altitude of 7,000 to 12,000 feet above sea level. Although this tree may not reach the girth of Deodar (*Cedrus deodara*), it frequently surpasses it in height, which in large trees may be more than 200 feet. It grows in admixture with Silver fir and forms extensive forests in the Western Himalaya.

It may be noted that the timber of the Himalayan spruce is almost similar to that of the European spruce. It makes excellent planking for walls, floors and ceilings. It is also used in making packing cases, tea chests, etc. It is also employed for making matches, match boxes and also for the making of paper pulp. There is one defect with this timber in common with Deodar that it gets rapidly waterlogged, and sinks and thus cannot be recovered.

The annual yield of total timber and fuel averages from all sources about 350 million cubic feet.

Trade in Timber:—The trade in timber in India is in the hands of contractors who carry out the contracts under the supervision of the Forest Department. The last census shows that over one and a half million people and their dependents are employed in India in various operations and industries connected with forests.

The following table shows the import and export of foreign timber in cu. tons for the year 1938-39.

Province	Timber imported			Timber exported		
	Teak	Other timber	Total	Teak	Other timber	Total
Bengal	52,096	7,571	59,667	81	7	88
Orissa	2	..	2	..	..	..
Bombay	56,737	14,154	70,891	2,048	372	2,420
Sind	12,998	3,131	16,129	3	1	4
Madras	38,062	671	38,733	249	269	318
Total	159, 895	25,527	185,422	2,381	649	3,030

It will be observed from the above table that the imports comprise only about 185,000 tons of timber or about 2 per cent. of the total timber produced from the Forest Department including the private forests. Even this 2 per cent. included teak from Burma which is hoped to be replaced by teak grown in India. There is some inter-provincial trade in timber. On the whole it may be concluded that, excepting teak, Indian forests can meet the requirements of the general consumer.

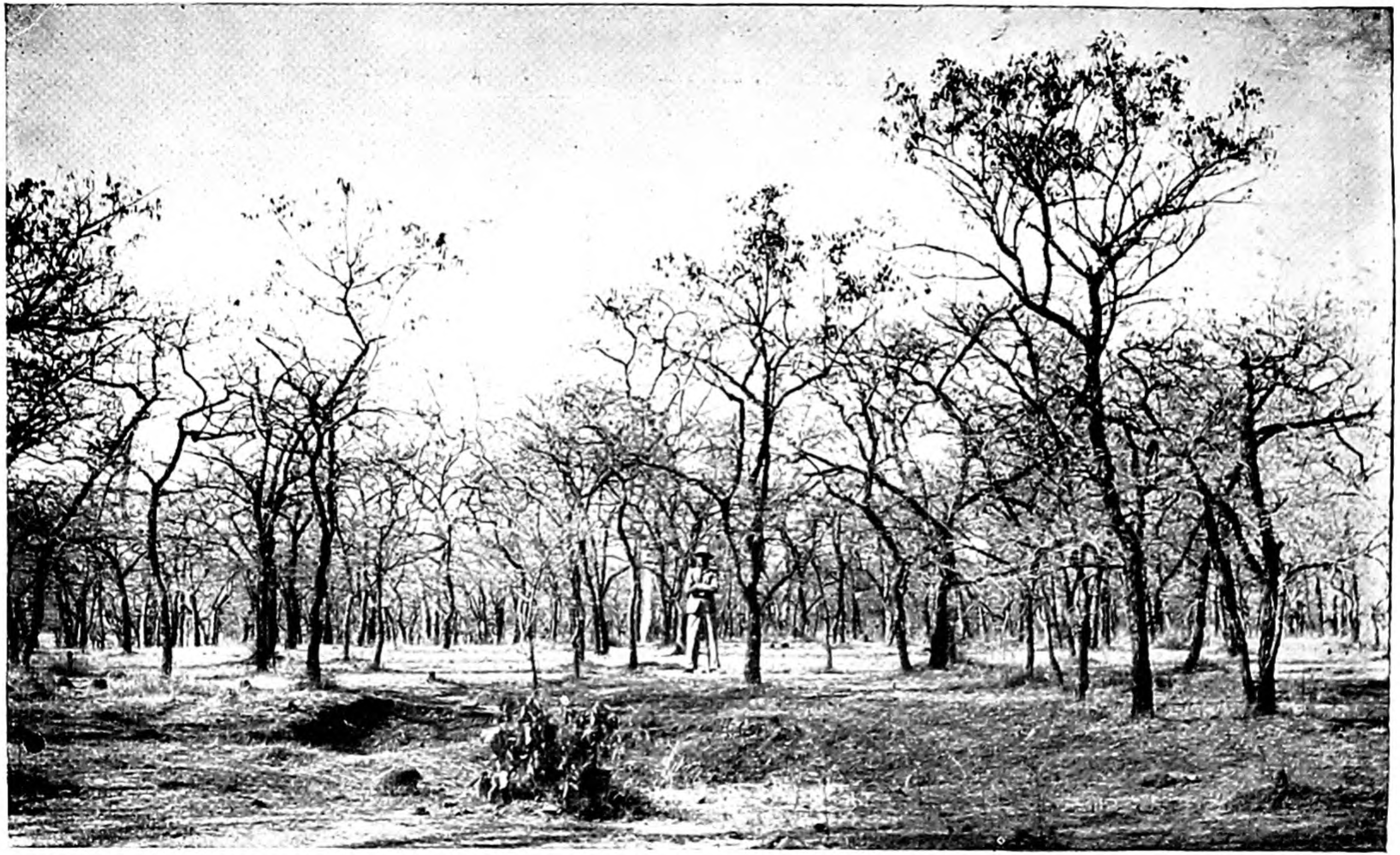
The following figures give the value of the imports of timber and manufactures connected with it for the year 1937-38.

Imports		*Value in Rupees*
Teak	....	2,17,59,000
Deal and pine	....	14,97,000
Other timber manufactures	....	34,01,000
Tea chests	....	71,70,000
Wood pulp	....	17,17,000
Matches	....	20,44,000
Other manufactures, excluding furniture, cabinet ware, re-exports	....	28,19,000
Rosin	....	4,52,000
Turpentine and substitute	....	7,56,000

The following figures give the annual value in rupees of the exports of forest products from India for the two years preceding the Second World War.

	1936-37	*1937-38*
Lac	2,34,21,000	1,62,18,000
Rubber	1,04,03,000	83,83,000
Myrabolans[1]	42,94,000	51,81,000
Sandalwood[2]	34,00,000	23,95,000
Cardamoms	18,25,000	31,52,000
Cutch[3]	5,65,000	60,000
Rosin	2,06,000	58,000

1. Includes extracts.
2. Includes oil.
3. Includes gambier.



Acacia Catechu (Khair) with *Boswellia serrata* on heavily grazed stiff black botton soil, Harsud-Khandwa Road. Nimar Division, C. P. (*Photo: K. P. Sagareiya*).

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Chapter IX

NATURAL VEGETATION AND

FOREST RESOURCES (*Contd.*).

Minor Forest Products

The minor forest products include grass for grazing, thatching purposes paper making and also for manufacturing some essential oils, bamboos, leaves, fibres, tanstuffs, resins, gums, rubber, *Katha*, some drugs and spices. Other minor forest products, e.g., pyrethrum, ephedrine, santonin, quinine from cinchona bark, rubber from Hevea, etc., obtained from annual and perennial herbs and trees, may be also mentioned. The most important minor forest products, however, comprise bamboo and grass. These two play an important role in rural economy, but now with the development of paper industry in India, an extensive use has been found for these in the manufacture of paper pulp. The lac industry has been treated separately in the sequel. From the forests are also obtained oils from the seeds, essential oils used in perfumery, medicinal plants, dyes and colouring material, fibres and flosses. It may be stated that excellent research work on these minor products is being done in the Bio-chemical laboratory of the Forest Research Institute of India.

From the seed of the Mahua, which flourishes in the Central Provinces and Bombay, oil is extracted,

which apart from consumption in India, is exported to England and Germany.

The Chalmugra grows in the Khasi hills and in Sibsagar and its oil is prized much for medicinal purposes.

Tanning Materials:—The principal tanning materials, which are available in large quantities in India comprise both the bark and the pods of Babul (*Acacia arabica*), Tarwood, Mangrove barks and the Myrabolans. These are used greatly for internal consumption and are also exported in large quantities to foreign countries. The quantity exported in 1936–37 was 1,209,110 cwt. which fetched Rs. 35,74,637. The bark and pods of Babul are consumed in tanning the sole leather and are used largely at Cawnpore, and their efficiency is considerably increased when Myrabolan is used with them. The bark of the Tarwood tree is the standard tanning agent used in Southern India.

However, the production of these tanning materials in India is not adequate and tanning materials, chiefly wattle bark valued at Rs. 1,500,000 are imported annually from Natal. It is alleged that attempts are being made to make the country self-sufficient by trying to grow the species required in India.

Perfumes and Oils :—India has been renowned for her matchless perfumes, *itars*, etc. from very ancient times. India has held for instance monopoly of sandalwood oil and Mysore at present supplies the foreign demand. The provinces of Bombay and Madras export the wood only.

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Resin Tapping Experiments in Western Almora Division, U.P.

Palmarosa Oil :—Another important oil, which India exports to foreign countries, is the palmarosa oil manufactured from the Rosha grass. This oil is used largely in the manufacture of synthetic perfumes, but the oil is not extracted on modern lines and there is great scope for improvement in the quality and the yield of the oil.

Lemon Grass Oil :—In south-western parts of India, especially in Travancore, Cochin and the adjoining portions of Malabar, the lemon grass is extensively cultivated for the extraction of its oil. The United States of America are the largest purchasers, while the United Kingdom, France and Germany buy the remaining half. India exported 7,066 cwt. of this oil in 1935-36.

Another important essential oil for use in perfumery, for the manufacture of which large quantities of raw materials are available in India, is Linalol.

Rosin and Turpentine :—An important industry in the Kumaun Himalayas is the tapping of rosin from its pine forests. It may supply in the near future the home demand of turpentine and resin. Bhowali, which is 5,500 feet above sea level, has an abundant supply of water as well as of pine from the neighbouring forests. The Chir pine (*Pinus longifolia*) occupies an area of 3,300 square miles, while the other varieties cover again a similar area.

At present there are two distilleries in India, one at Jallo, a few miles from Lahore and the other at Bareilly in the United Provinces. It is stated that both these

factories utilise annually about 88,484 cwt. of crude resin from which 144,212 gallons of turpentine and 59,254 cwt. of resin are manufactured. The final product is reported to be not inferior to the American and French turpentine.

It may also be added that Salai or Guggar (*Boswellia serrata*), which grows abundantly in Bihar, Orissa, Rajputana, Central India, the Central Provinces and the Deccan, produces a substitute for turpentine. It may have an importance in the manufacture of paints and varnishes.

Transport Facilities

It is alleged that the development of forests in several parts of India is handicapped for want of proper transport facilities. Where suitable roads have been constructed, timber is transported in carts drawn by bullocks or buffaloes. In more dense forests of Assam, the Andamans, etc. the hauling of timber from the jungle to the rivers is done by elephants. In certain regions forest tramways have been built, e.g., in the Changa Manga reserve of the Punjab, in the Central Provinces and in Goalpara in Assam. Similarly, ropeways are employed in the Rawalpindi forests of the Punjab and near Cherrapunji in Assam. The streams and rivers, especially during the rainy season are used for floating timber and bamboo rafts to the markets.

Forest Industries

Sawing of timber :—Sleepers for railways, etc., are

Cochin Forest Tramway, No. 3 Incline, length 1,300 feet, Cochin State.

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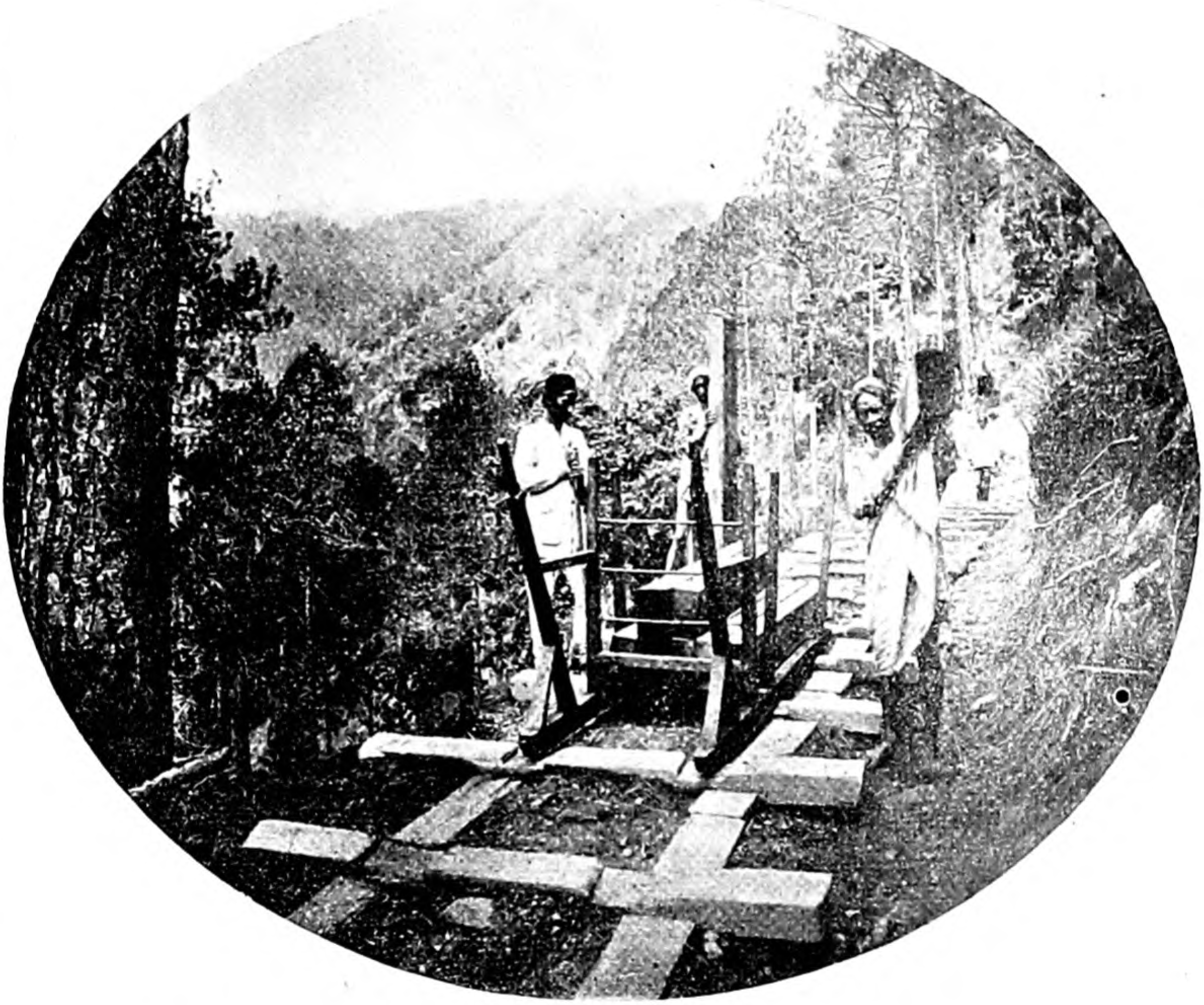

Lower Sledge Road Depot, Jaunsar, U. P.

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sawn in the saw mills situated near the forests. The location of these saw mills by provinces is as follows :—

Assam	8
Bombay	3
Central Provinces	2

Furniture making is carried on in almost all important towns of India.

Coconut and Coir Industry

The coconut palm flourishes very extensively, e.g., on the West Coast of India, the deltaic region of Bengal, etc. This plam is very useful with its fruit, the kernel, shell and coir[1] of which are all in great demand. From the kernel the coconut oil is extracted and it is also used in making sweetmeats. In certain parts the juice of the coconut is fermented into a toddy liquor. It has recently been discovered that the ash of the shell can be employed with advantage in making gas masks. Besides, it has a host of domestic applications, whilst the coir is largely used in making ropes, matting, etc. India and Ceylon have a virtual monopoly of this coir industry and the manufactured articles are exported to the United States of America, the United Kingdom, France, Germany and Holland. The manufacture of coir matting is a very important industry of the States of Travancore and Cochin, Malabar Coast, and the annual exports from Travancore alone are valued at two crores of rupees.

1 Coir is the trade name given to the fibre obtained from the husk of the coconut.

The extraction of fibre and the manufacture of coir yarn is an important cottage industry of this region and the work is chiefly done by women in their leisure hours. The husk is first retted, washed and made into fibre which may be baled in factories as such for export or may be manufactured into ropes, matting, door mats, braid, ship fenders, rugs, etc. The ropes thus manufactured are very strong and elastic. This industry provides a profitable occupation to the densely populated backwater regions of Malabar Coast. It also supplies yarn and fibre for a considerable industry in Europe.

It forms a valuable item of export from India. The imports of Great Britain alone, which represent less than 20 per cent. of the whole, are valued at about one and a half crore of rupees.

It may be noted that there is scope for the expansion of the industry on the East Coast.

The United States of America has levied heavy import duties on this material which has affected the industry adversely. All the exports pass through the ports of Cochin, Alleppey and Calicut.

Lac Industry

The lac industry of India can be traced back to very ancient times when dyes were prepared from it. The discovery of synthetic dyes affected the Indian industry tremendously, but the find of other uses of lac has regenerated the demand to a certain extent. At present it provides an important export trade in lac of the annual value of over two crores of rupees. Lac

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Type of pure *Butea frondosa* (*Dhak* or *Palas*) forest on badly drained soil near Deraseoni, Balaghat Division. All trees are tapped for lac. (*Photo*: *M. V. Laurie*).

is used in the manufacture of shellac which finds application in the making of gramophone records, French polish, hats, leather dressings, grinding wheels, sealing waxes, varnishes for insulating purposes in electrical machinery, and also for lacquer industry which is carried on so extensively in Burma. Shellac is manufactured from the lac which is a resin exuded by the insect (*Laccifer lacca*) which lives on twigs of trees like Palas (*Schleicher trijuga*), Kusum (*Bhutea frondosa*) Ghont (*Zizyphus xylopyra*) and Ber (*Zizyphus Jujuba*). It has been found that the lac insect usually thrives at altitudes of 1,000 feet above sea level enjoying moderate temperatures and a rainfall not in excess of sixty inches a year. The annual output of raw lac from India is about 50,000 tons which on refining produces 25,000-35,000 tons of shellac and seedlac. The Chota Nagpur region alone furnishes nearly 87 per cent. of the total output, while other areas, where this industry is carried on are Orissa, Santhal Parganas, the Chattisgarh Feudatory States and several districts of the Central Provinces. In Bengal, in the districts of Murshidabad, Bankura, Birbhum and Maladah, this industry is known to be practised. Some parts of the United Provinces, Sind and Assam also produce lac.

In certain regions the industry suffers from lack of proper transport facilities and also the growing of lac is in the hands of the ordinary cultivators who abandon the enterprise in times of slack prices. The principal collecting centres of stick lac are Balarampur (U. P.) and Jhalda in Manbhum, Ranchi and Imamganj in Gaya (Bihar), Garha in Palamau, Pakur in Santhal Parganas, Bhandara, Raipur and Katni (the Central Provinces),

Ahraura in the Mirzapur district (United Provinces) and Umaria in Central India. The collections of stick lac are then sent to centres of manufacture, viz., at Mirzapur, Jhalda, Balrampur, Pakur, Umaria, Imamganj and Ranchi. Mirzapur is the most important manufacturing centre with 40 factories which employ nearly 3,500 hands. The manufactured shellac is exported from Calcutta. Orange Shellac is the important export, while garnet lac and button lac constitute about 5 and 3 per cent. of the exports respectively.

Buyers of Shellac :—The United States of America are the best buyers of shellac with their intake of 60 per cent. Next comes the United Kingdom while, Germany, France and Japan are also important importers. About 10,000 tons of shellac are used in the manufacture of 200,000,000 gramophone records.

Lac Research Institute :—There is the Indian Lac Research Institute at Namkum, near Ranchi which has been engaged in investigating improved methods of producing lac and finding new uses for it. Plastics, oil-cloth abrasive papers, laminated boards, baking insulating varnishes are some of the new materials made from lac.

Competition from Neighbouring Countries.

India's position in regard to the lac industry is being challenged by Siam, which has made remarkable progress in this industry during 1946 and 1947. Before the last War India produced 90 per cent. of the word's supply of lac; the remaining 10 per cent. was produced in Siam, Indo-China and Burma. However,

the refining of raw lac into shellac and seedlac was the sole monopoly of India and the other lac-producing countries sent their raw lac to India for refining.

Siam is now not only producing more lac, but is also manufacturing shellac for direct export to the United States of America and other countries. Compared to a pre-war average annual export of 5,000 tons of stick lac mostly to India from Siam, about 10,000 tons of stick lac and 1,500 tons of shellac were exported from Bangkok during the first nine months of 1947 alone. This is equivalent to about 25 per cent. of India's total production. It may be further noted that the quality of the Siamese shellac is improved, while its price is about two-thirds of that of Indian shellac. Siam has started factories to produce 6,000 tons of shellac *per annum* which represents nearly one-third of India's production. These facts indeed serve a warning to the lac industry of India to endeavour to improve quality, increase production and keep the prices normal. This industry already faces a menace of replacement by synthetic resin, but the competition in prices from neighbouring countries has also become serious.

Paper Manufacture

In 1938–39 a new record in the manufacture of paper in India was established with an outturn of 1,184,000 cwt. as against 1,076,000 cwt. produced in 1937-38.

Hand-made paper is an ancient industry of India. In Kashmir coarse paper is known to be made from rags

and papers. At Arwal in Bihar, in Dacca and at Muttra in the United Provinces hand-made paper industry even exists today on a small scale. In 1867 the first paper mill was established on the Hooghly. By 1882 three paper mills had come into existence and in 1925, when the first appeal for protective tariff was made, nine mills had been established and two were in project. But now owing to the growing demand for paper, 13 mills have been established in the various provinces of India, viz., Bengal 3, United Provinces 2, Bihar 1, the East Punjab 1, Bombay 2, Southern India, 4. Another paper mill is being established in Hyderabad-Deccan.

Paper is manufactured in these mills with wood pulp imported mostly from Europe. They also employ local grasses for the manufacture of the inferior qualities. The paper consumption in India is very low *per capita* and it is compared with that of other countries below :–

United States of America	152 lb.
United Kingdom	81 lb.
Germany	48 lb.
France	40 lb.
Japan	18 lb.
Egypt	5 lb.
India	1 lb.

India manufactures about 40,000 tons of paper, while over 100,000 tons are imported from abroad, viz., the United Kingdom, Germany, Belgium, Norway and Sweden.

The supply of raw materials, good water, cheap

labour and nearness of a market are the essential conditions for the thriving of paper industry. In India, the raw materials required are pulp made from wood, grass and rags and coal is required to run the machinery.

Grass Pulp :– As referred to above, paper is made from grasses, e.g. , the *Bhaib*, *Sabai* or B*habar* and *Ulla* grass. Sahebganj and Bettiah are great exporting centres in Bihar and furnish the requisite supplies to mills in the neighbourhood of Calcutta and Lucknow. The Saharanpur and the Dehra Dun Forest Divisions supply the requirements of the factory at Saharanpur. Paper can also be manufactured from Moonj (*Saccharum Moonja*) and it appears to have held the field in the beginning as it makes very good paper. In sugar cane growing regions, leaves of sugar cane are also used as a raw material.

Bamboo Pulp :– The possibilities of making pulp from bamboo have been tried which have yielded very encouraging results, thus promising a great future for India's paper industry. Bamboo is found extensively in several regions in India, e.g. , in Assam, in the Himalayan Terai, in the Sunderbans, in several parts of Orissa, Madras and Kanara in Bombay. The cost of manufacturing paper from bamboo pulp is lower than that from imported pulp and it has been estimated that India can manufacture ten million tons of bamboo pulp a year. Paper mills have already been established at Chittagong, Dalmianagar and Rajahmundry, all near the great centres of Bamboo forests. Bamboos have a great advantage over soft woods in as much as there can be a rotation of four years in the case of bamboos

as compared to 60 years for most species of wood. One difficulty with bamboos is that when they seed, they die. But it is only gradual and does not affect all species simultaneously. It may be noted that the manufacture of pulp from bamboo is at present exclusively confined to India.

Wood Pulp :- In countries, which manufacture wood pulp on a large scale, coniferous woods represent largely the raw material. Coniferous forests with species of pine, fir and spruce occur on the higher slopes of the Himalayas and, therefore, present difficulty of extraction and transport. Spruce and fir occur practically in inaccessible regions, except in Kashmir. Pinewood, therefore, offers greater promise.

A certain amount of bleached or unbleached pulp is imported from abroad which is used in admixture with pulp made from indigenous materials in India.

Bengal has an extensive area under paddy and manufacture of paper from its straw is well worth a trial. Wheat straw is used by some mills in Nothern India for the manufacture of strawboard, paper, etc.

Process of Manufacture :—The raw materials, grasses, cloth rags, etc. are digested with chemicals to form pulp. In case of bamboos, from which manufacture of paper is exclusive to India, raw bamboos are chipped or preferably crushed in a series of rollers. The disintegrated fibre, thus prepared, is digested with chemical reagents. These comprise two processes which may be styled the alkali and the acid processes. The alkali used may be caustic soda or sodium sulphate in admixture

with small quantities of caustic soda. The digested pulp is then thoroughly mixed, beaten, washed and bleached. The pulp thus made is spread on paper machines to emerge finally as paper.

Manufacture of Strawboard:—An allied industry is the manufacture of strawboard or millboard. Raw materials used are practically the same as in the case of paper and the process of manufacture is similar; only in the case of strawboard bleaching is not affected.

The present capacity of paper mills in India is stated to be a little over 100,000 tons, provided the required supplies of coal and chemicals are available. As the annual consumption increases by 10,000 tons, there is a great scope for the expansion of this industry. The paper manufacturers so far have devoted their attention to serve the home market, but the time is now mature when they should explore the potentialities of export market.

Manufacture of Newsprint:—India has to import her total requirements of newsprint from abroad as it is alleged that she does not possess the requisite raw materials. However, recent investigations have shown that Kashmir and Tehri Garhwal States can supply adequate quantities of spruce and fir for establishing a paper mill in each of these States. Preliminary tests with regard to the suitability of these woods have been carried out at the Forest Research Institute, Dehra Dun. There are difficulties, however, in importing machinery from abroad, which are proving handicaps in the materialisation of these projects.

Match Industry

Before the manufacture of matches, man used to obtain fire by striking with flint, but now matches have proved so convenient and cheap that they have come in popular use.

India used to obtain large quantities of matches from Sweden and Japan before the first World-War of 1914-18. In 1921 she imported matches valued at over two crores of rupees to which Japan had a share of more than Rs. 1,85,00,000. Match industry in India is about 20 years old. The Government of India levied a high protective duty on imported matches for purposes of revenue. It gave an impetus to the Indian industry.

Suitable wood for the manufacture of boxes is available in India, but the wood used in the manufacture of splints should not be fragile and should be able to absorb paraffin wax. Recent investigation has shown that sufficient supplies of wood with these qualities exist in different parts of the country.

Output in India :—The present output in India is approximately twenty million gross of boxes. It represents over 99 per cent. of India's requirements.

Silk Industry

Silk weaving is an ancient cottage industry of India and she had an important export trade in silk. This export trade has disappeared and in normal times she imports large quantities of silk from China and Japan, the former's share being greater than that of the latter inspite of the tariff duty.

Silk yarn is produced from cocoons by silk worms which live on the leaves of trees like mulberry (*Morus* spp.), Mahua (*Bassia latifolia*), Sal (*Shorea robusta*), Kusum (*Schleichera trijuga*) and Ber (*Ziziphus Jujuba*). There are three kinds of silks produced in India : (i) the Tasar, (ii) the Muga (glossy yellow) and (iii) the Eri silk, which is the whitest in colour.

The cultivation of mulberry is done by the *ryot*, either in the form of cultivating bushes or in the form of planting trees. The cocoon-rearing is done by the hill-tribes of the Santhal Parganas, Orissa States, Assam and Mysore.

Silk-Weaving Centres :- Silk-weaving is done at several places in India. In Bengal silk cloth is made at Midnapur, Jehanabad, Birbhum and Murshidabad and the production is valued at Rs. 20,00,000. In the districts of Sambalpur (Orissa) and Singhbhum (Bihar) silk cloth is woven. Bhagalpur is famous for its *bafta* silk and obtains its cocoons from the Santhal Parganas and also from the districts of Palamau and Hazaribagh. The production of silk from Bihar and Orissa is valued at Rs. 42,00,000. Golaghat, Jorhat and Sibsagar are the chief centres in Assam. Ludhiana in the Punjab is an important silk-weaving centre. Benares is a very important silk-weaving centre in the United Provinces. At Bangalore in Mysore and at Srinagar in Kashmir silk-weaving is well established. The silks of Mysore, in fact, are very well known. The production of Tasar silk in the Central Provinces is valued at Rs. 14,00,000. There are six mills in India, viz., two in Bombay, one each at Benares, Calcutta, Ahmedabad and

Bangalore and their output along with those of the handlooms is generally consumed locally. The new Eri silk industry in Baroda is developing.

The value of production of silk in rupees in important centres is tabulated below :-

Mysore	38,00,000
Kashmir	10,00,000
Madras	5,00,000
Jammu	2,00,000

It may be observed that the industry, in general, is on the decline. It is progressing only in Mysore and Kashmir. It is believed that suitable tariff duty on foreign silks will help to revive the silk industry of India.

Tung or Chinese Wood Oil Industry

India consumes large quantities of Tung Oil, also known as the Chinese wood oil, but most of it is imported. It is used in paint and varnish industry and also as an important constituent in leather dressing. It makes one of the best water-proof coatings. It is also used as a lubricant.

This industry was the monopoly of China. The trees grow in the mountainous tropics and sub-tropics. The annual yield varies from 25 to 125 lb. according to the age of the tree.

During the year 1936, 60,000 tons of this oil were exported to the United States and large quantities to the United Kingdom and India.

The United States of America started plantations in

the beginning of the century and now has 100,000 acres under Tung trees.

Assam and Bihar are the two provinces where success has attended in growing these trees. There are 1,200 acres under Tung at Naogaon in Assam besides 350 acres in several tea estates. The Tung trees also occur at Dehra Dun in the United Provinces and also in the North-West Frontier Province.

Young trees in their second or third year begin to bear fruit, but the yield sets on a commercial basis when the trees are 5 years old.

The oil obtained in China is a little dark in colour and is seven per cent. acidic, but in the United States of America and British Empire the oil is of light colour and is neutral in reaction.

Plywood Industry

Plywood industry is developing in India. In this case the weight of the wood is very low, while its strength is considerably augmented. The procedure of manufacture is very briefly as follows. Logs of wood are sawn into pieces of suitable size and the bark is removed. It is then taken out into large thin shavings. These are cut into pieces of suitable size. Then these pieces are fixed together by means of an adhesive gum and glue in such a manner that the two adjoining pieces have the grain of the wood at right angles to each other. This arrangement imparts great strength to the plywood.

In India several large and small scale factories for

its manufacture have been established. For instance, at Sitapur in the United Provinces, there is an important factory engaged in this manufacture. Similarly, there is another factory at Dalmianagar in Bihar where again large scale manufacture of plywood is carried on.

Conclusion

Forests undoubtedly play a very important role in the prosperity of a country. They are required for purposes of climatic and physical conditions. In this country only about 14 per cent. of the total area is under forests of which only 9 per cent. is merchantable. To this may be compared the average area of about 26 per cent. in European countries. An attempt should be made to achieve a similar percentage for India and, allowing for general configuration, the area should be equally distributed over the provinces. Increased areas can be brought under forests by afforesting waste lands, both Government and private, particularly the ravine lands, which have not been reclaimed for agriculture.

India definitely needs more forests to supply her requirements of timber and firewood, particularly the latter which is badly needed to save the cowdung required as a manure. There are various estimates of the cowdung burnt in India. According to the estimates of the Indian Council of Agricultural Research 560 million tons of cowdung are burnt *per annum*. This shows what a colossal amount of cowdung can be saved which plays such an important role in the agricultural economy of India. There is testimony

to show that about $3\frac{1}{2}$ tons of this manure per acre roughly double the yield. It will be, therefore, apparent what increase in the outturn of food and other crops will be possible, if this cowdung could be saved for cultivation purposes.

CHAPTER X

MINERAL RESOURCES

The present age has been aptly styled as 'the Age of Minerals' as it is these minerals which supply the basic raw materials for industries. There is hardly any doubt that India's mineral wealth is both varied and great.

In the first issue of *Indian Minerals*, p. 4, the minerals of India have been divided into four groups. The first group comprises iron ore, titanium and thorium ores and mica. She is very rich in these and her export surpluses are of world importance.

The second group, enumerated below, in alphabetical order comprises those minerals in which she is rich and has important exportable surpluses : bauxite, beryl, corundum, gypsum, magnesite, manganese ores, monazite, monumental granite, mineral abrasives, refractory materials, silica and steatite. In the following minerals, which form the third group, India may be considered as self-sufficient for the present requirements and the immediate future : antimony, arsenic, barytes, building stones, cement materials, clays, coal, chromite, dolomite, felspar, gold, limestone, marble, mineral pigments, nitrates, phosphates, pyrites, precious and semi-precious stones, rare earths, slate, sodium salts and alkalis, vanadium and zircon.

India is very deficient in the following fourth group of minerals and has to depend largely or entirely on imports : asphalt, copper, fluorspar, graphite, lead, mercury, molybdenum, nickel, petroleum, platinum, potash, silver, sulphur, tin, tungsten and zinc.

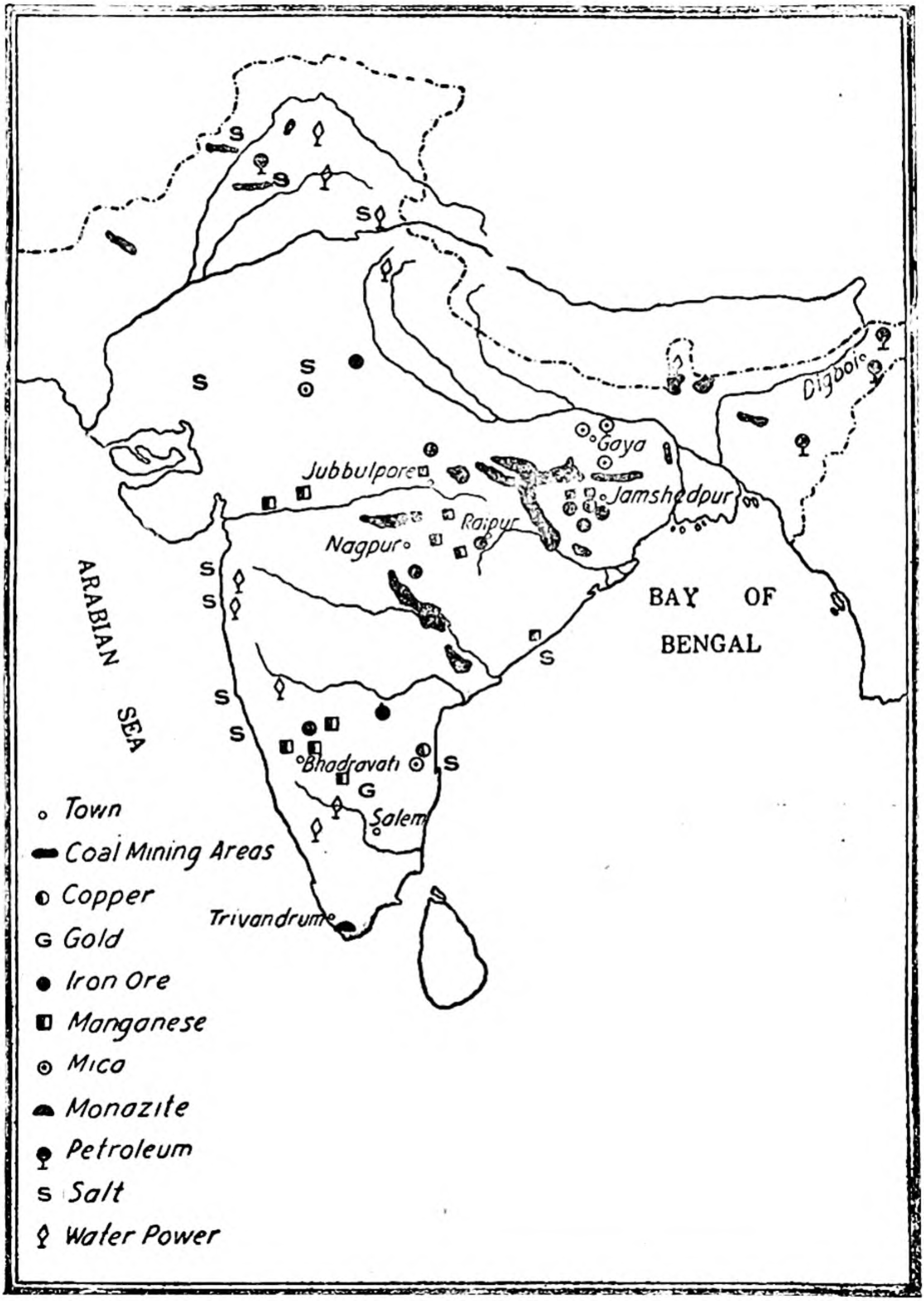


Fig. 21—Showing geographical distribution of Important minerals of India.

These minerals are associated with different rock formations. A concise account of the geological formations of India has been given in Chapters XIV and XV of Part I of this work. A great majority of these minerals like iron ores, manganese ores, gold, etc. occur associated with the rocks of the Dharwar age. The geographical distribution of important minerals is shown in Fig. 21.

Importance of Mineral Industry

The following table gives the value in crores of rupees of important minerals and metals produced in 1938, the last pre-War Year and 1944 together with their export position. This will also give an idea of the annual wealth accruing to the country on account of exploitation of minerals (See Fig. 22). It will be observed that the pre-War annual income amounted approximately to 34 crores of rupees, while the same figure for 1944 has been 72 crores of rupees.

	1938	1944	Export Position
1. Coal	10.64	27.24	Small exports to Colonies.
2. Iron and Steel	10.40	26.78	Small exports of pig iron.
3. Manganese ore	3.92	4.30*	Over 90% exported.
4. Gold	3.04	3.55	Largely exported.
5. Petroleum	1.65	1.78	Small exports.
6. Mica	1.13	2.73	Wholly exported.
7. Building Materials	1.12	2.25	
8. Salt	0.95	2.46	
9. Copper	0.44	0.67	
10. Ferro-manganese	0.24	0.08	
11. Ilmenite	0.15	0.16*	Wholly exported.
12. Saltpetre	0.11	0.10	Largely exported.
13. Kyanite and Sillimanite	0.07	0.07*	Wholly exported.
14. Chromite	0.06	0.07	Largely exported.
15. Industrial clays	0.03	0.13	
16. Monazite	0.02	0.02*	Wholly exported.
17. Gypsum	0.01	0.03	

	1938	1944	Export Position
18. Steatite	0.016	0.05	Largely exported.
19. Magnesite	0.016	0.05	
20. Fuller's Earth	0.007	0.02	
21. Diamonds	0.006	0.02	
22. Rutile		0.02	Wholly exported.
23. Zircon	0.004	0.02	Wholly exported.
24. Barytes	0.003	0.018	
25. Ochres	0.003	0.015	
26. Antimony		0.015	
27. Graphite	0.002	0.013	
28. Asbestos		0.012	
29. Beryl		0.01	Wholly exported.
30. Tungsten Ore	0.001	0.009	
31. Corundum		0.008	Largely exported.
32. Bauxite	0.002	0.006	
Total	34.040	72.706	

* Pre-war figures.

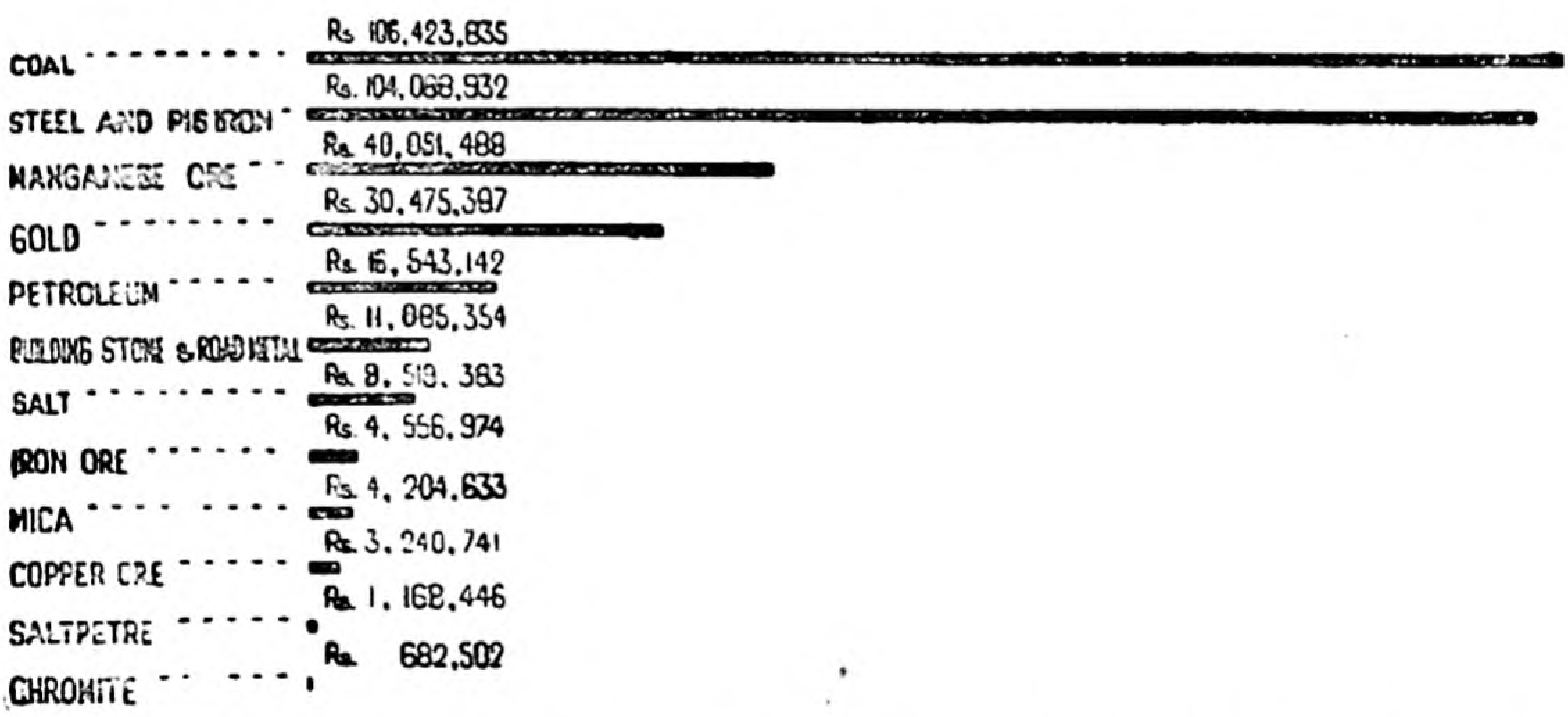


Fig. 22.—Showing the annual value of the important minerals produced in India.

A brief account of the important minerals occurring in India is given in the sequel.

Iron and Steel

Smelting of iron and the manufacture of steel in India is a very ancient industry. *Wootz* steel, for which India acquired a reputation, dated back to long before

the Christian Era. Sporadic attempts to manufacture iron and steel using charcoal fuel were made in the nineteenth century, but the enterprise did not prove successful. Iron and steel manufacture on a commercial scale by European processes was again started by Messrs Tata Sons & Company at Jamshedpur in 1911 when the industry received an impetus; the total output of iron ore for that year increased from 42,653 tons in 1910 to 342,342 tons in 1911

It is stated that India's resources of high grade iron ore are perhaps the largest in the world. The output and value of iron ore produced in India for the year 1937 is shown below :-

	Tons	Value in Rupees
Bihar : Singhbhum	1,587,362	27,30,077
Central Provinces :	354	1,062
Eastern States Agency		
Keonjhar State :	307,935	3,18,646
Mayurbhanj :	942,701	14,31,760
Mysore	32,480	1,04,833
	2,870,832	45,86,378

The production of iron ore is approaching 3 million tons *per annum*. So far it has been consumed by the Tata Iron and Steel Co., and the Indian Iron and Steel Co., near Asansol. In 1938 there was an export of one million tons of iron ore to Japan.

Although India's production of iron and steel is next to that of the United Kingdom, it is small in comparison to that of the U.S.A. and France as shown below :-

	1935		1936	
U.S.A.	30,500,000	tons	48,750,000	tons
France	32,300,000	,,	32,300,000	,,

It may be observed, however, that, as noted in the sequel, the Government of India wish to expand the iron and steel industry. In spite of a tremendous general increase in the prices of raw materials and enhanced wages of labour, cost of iron and steel production in India is still the lowest in the world.

A belt of rich iron ore extends over the southern area of Bihar and Orissa which represents one of the richest and most important iron ore deposits in the world. Valuable deposits of iron ore also occur in the Central Provinces. At present the following concerns are engaged in iron smelting on modern lines.

1. *The Indian Iron and Steel Company, Limited:*— This concern was started a decade after the Tatas. During the year 1936 the Indian Iron & Steel Company, Ltd. with its works located at Burnpur, two miles W. S. W. of Asansol and the Bengal Iron Company, Limited, Kulti amalgamated.

2. *Tata Iron and Steel Company Limited, Jamshedpur.*

3. *Mysore Iron Works, Bhadravati.*

The output of pig iron in India during the years 1936 to 1938 is given below :—

	1936	1937	1938
	Tons	Tons	Tons
1. The Tata Iron & Steel Co. Ltd.	858,272	885,393	988,345
2. The Indian Iron & Steel Co. Ltd.	659,543	713,030	540,277
3. The Mysore Iron Works, Bhadravati.	22,241	22,837	11,267
Total	1,540,056	1,621,260	1,539,889

The Indian Iron and Steel Company, Limited obtain their supplies of iron ore from their mines at Gua in the Kolhan Government Estate in the Singhbhum district of Bihar. These mines can supply iron ore to the extent of 60,000 tons per month.

The Bengal Iron and Steel Co., Limited also obtain most of their ore now from the Kolhan Estate, Singhbhum district where this company secured some years ago two deposits known as Notu Baru and Buda Baru, south-east of Manharpur Station on the Bengal Nagpur Railway. Later prospecting has revealed the existence of numerous iron ore deposits in this region and in fact a belt, as noted above, extends for 40 miles in a S. S. W. direction into Keonjhar and Bonai States in Orissa. The total reserves of iron ore in the above two hills have been estimated at 10 million tons. The ore is a high grade hematite with an average iron content of 64 per cent.

Tata Iron & Steel Company, Limited have their works at Jamshedpur on the Bengal Nagpur Railway. Their furnaces can produce a total outturn of about a million tons of pig iron a year. Nearly 75 per cent. of the iron produced by the company is used in the manufacture of steel. Besides the amount of pig iron shown above the Tata Iron and Steel Company produced 665,309 tons of steel and 8,041 tons of ferro-manganese in 1937.

This company owns the following important iron ore deposits :-

(1) The Kolhan Government Estate in Singhbhum district, Bihar.

(2) Keonjhar State.

Before the development of Noamundi mine in Kolhan, their supplies were obtained from their nearest concessions in Mayurbhanj State. In this area with more than a dozen deposits of rich ore (See Fig. 23), the following three are the most important.

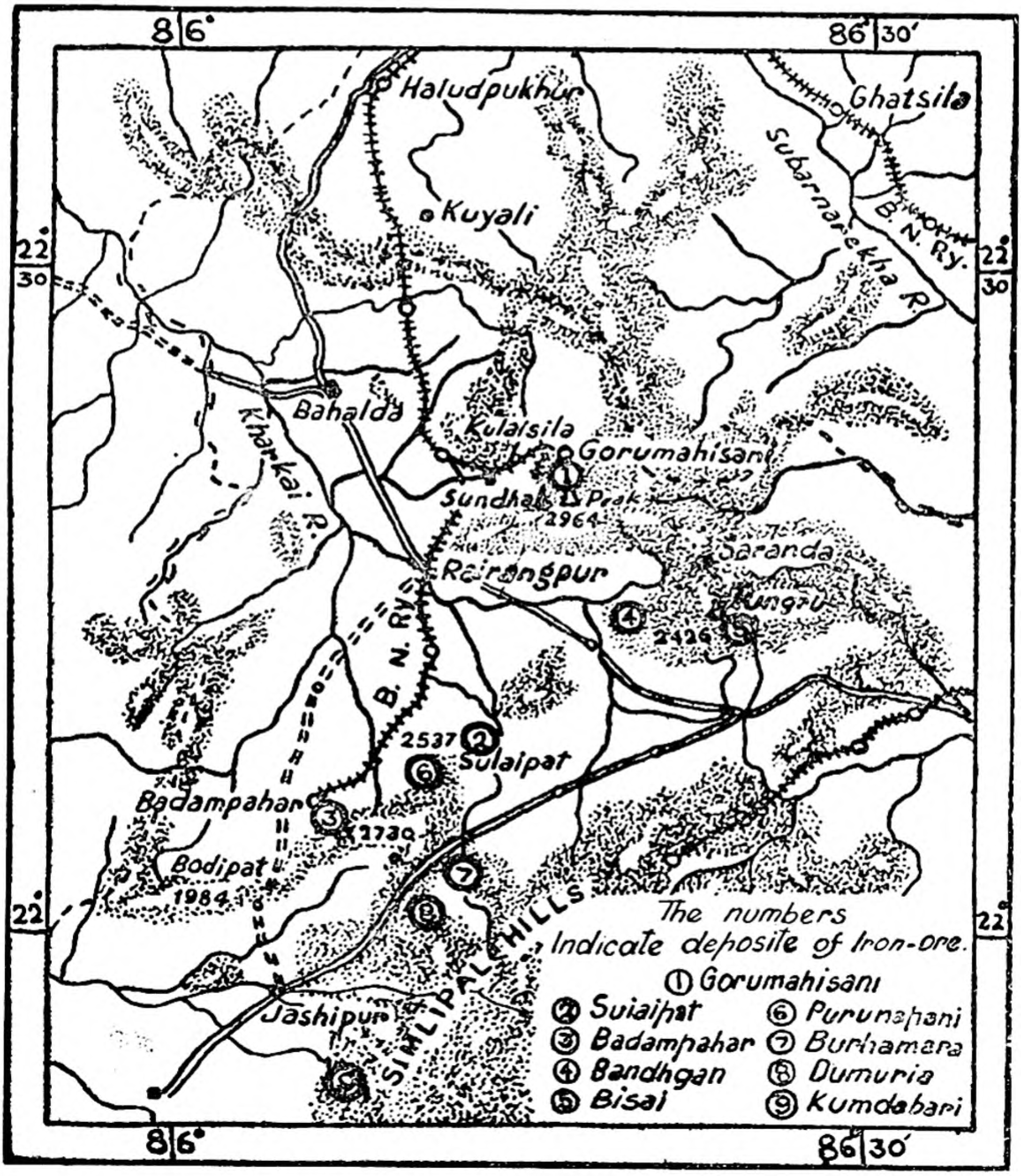


Fig. 23–Showing important Iron ore deposits in Mayurbhanj State.

1. *Gurumahisani* :- The large iron ore deposits of Gurumahisani, which are easily accessible, form a hill range with three peaks, the highest being 3,000 feet above sea level. The average iron content is about 63 per cent. The following table gives the analyses of both the 'float' and the 'solid' ore from Gurumahisani.

	Iron	Phos-phorus	Sulphur	Silica
Average of all samples, both solid and float ore.	61.85	0.135	0.036	4.08
Average of 20 samples of float ore.	61.45	0.048	0.036	3.34
Average of 10 samples of solid ore.	64.33	0.075	0.021	1.64

2. *Okampad and Sulaipat* :— These deposits, which culminate in couspicuous peaks and are a mile apart, occur 12 miles S.S.W. of Gurumahisani. The Sulaipat ore is very rich and is consumed both in open hearth and blast furnaces. An average analysis of the ore for 1933-34 is given below :-

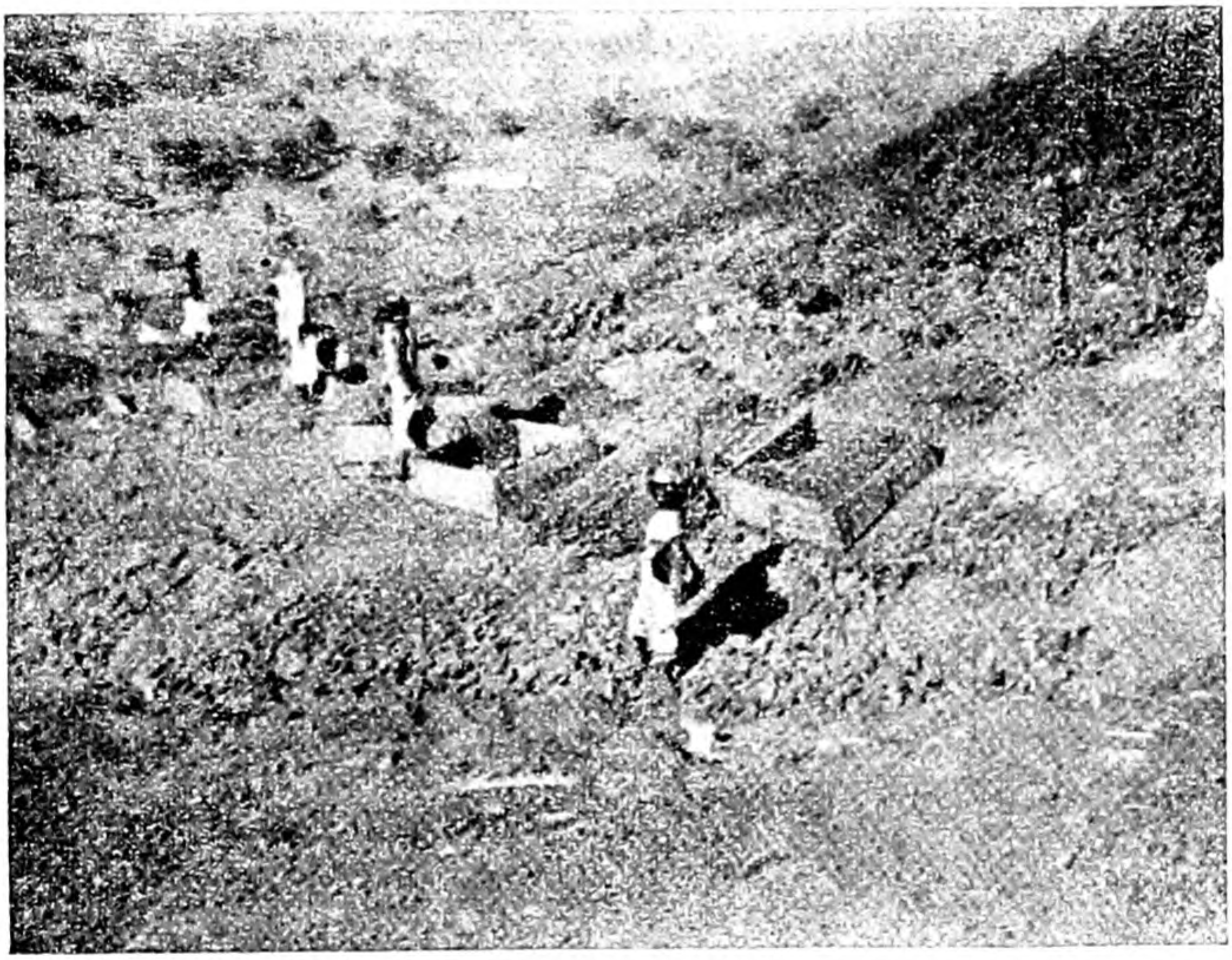
Iron	..	..	67.74
Manganese	..	..	0.24
Silica	..	..	1.72
Phosphorus	..	..	0.029

In 1915 the reserves of iron ore were estimated by Curnow as follows :-

Solid ore	..	..	1, 141,000 tons
Float ore	..	..	936,000 tons
		Total	2,077,000 tons

Fig. 2—Deadway tubs on the gravity rails ready to transport the iron ore from the quarries at Gurumahisáni down to the Camp. (*Photo: Vishwa Nath Chhibber*)

Fig. 1—Showing face of an iron quarry at F-level, Gurumahisani, Bihar. (*Photo: Vishwa Nath Chhibber*)



Showing iron ore being sorted at Gurumahisani quarries and filled in tubs to be transported by gravity incline to Gurumahisani Railway Station. (*Photo: Vishwa Nath Chhibber*)

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But the actual reserves are much larger than the above estimates. Up to the end of 1933, 1,421,197 tons of ore had been extracted. The working of the float ore has revealed new bands of iron ore. The ore is associated with banded hematite-quartzite and a fine-grained blackish quartzite. Granite forms the surrounding low lying area.

3. *Badampahar* :- The ore of this locality, which forms a hill, 2706 feet above sea level and $8\frac{1}{2}$ miles S. W. of the Sulaipat mine is somewhat porous though with a low iron content varying from 56-58 per cent.

The iron ores of Naomundi mine, Kolhan in the Singhbhum district consist of thick deposit of hematite, averaging considerably more than 60 per cent. of iron. An analysis of an average sample is given below:-

Iron	62.5	per cent.
Silica	about 4	per cent.
Alumina	about 3	per cent.

Consignments to the works with 69 per cent. of iron can be arranged. It means only 1 per cent. of impurities as theoretical composition of hematite represents 70 per cent. iron and 30 per cent. oxygen.

Reserves :- The following are the minimum reserves of iron ore in tons with about 60 per cent of iron.

Singhbhum District	1,047,000,000
Keonjhar State	988,000,000
Bonai State	648,000,000
Mayurbhanj State	18,000,000
Total	2,701,000,000

Thus about 3,000 million tons of high grade iron ore, averaging not less than 60 per cent. of iron, have been proved in the Singhbhum district of Bihar and the adjoining Eastern States. Besides there are other reserves. About 600 million tons have been estimated in the Bastar State. There are large deposits of iron ore in the Chanda and Drug districts of the Central Provinces, as referred to below. Likewise valuable deposits of iron ore occur in the Babubudan and other hills of Mysore.

Central Provinces

High grade, valuable iron ores occur in the Central Provinces in the districts of Drug, Chanda and Jubbulpore. A large area in the Dondi Lohara Zemindari in the Drug district is occupied by iron ores which form conspicuous hillocks, the most noteworthy being the Dhali and Rajhara hills. The analysis of surface and core samples have revealed 66 and 68 per cent. of iron respectively. In the Rajhara mass $7\frac{1}{2}$ million tons of iron ore with an average of 67 per cent. of iron have been proved, but it is believed that actually much greater quantities would be available. Besides, there are other masses which have not been subjected to such careful examination.

Chanda District :– Iron ores also occur in the Lohara hill of the Chanda district which is estimated to contain at least 2 million tons of high grade iron ore. The following analysis gives the average percentage composition :–

Iron	.. ..	61	to	67
Silica	.. ..	1.5	to	11

Sulphur	0.012
Phosphorus	0.005

Madras

Rich deposits of iron ore, composed of magnetite, occur in the Nellore and Salem districts of Madras. In the former district magnetite occurs in two group of hills, viz., (1) Ongole group comprising four or five bands of ore occurring in the Konijedu hills, at Ongole and in Parnametta hills. It is believed that these deposits run continuously underground beneath the alluvium. The second group forms the Gundakamma group where ore is exposed in a number of hills.

Very great reserves of iron ore occur in the Salem district. Holland[1] considered these deposits practically inexhaustible. The important deposits comprise the following:— (1) Godamalai, (2) Thalaimalai-Kolimalai, (3) Singapatti (4) Thirtamalai and (5) Kanjamalai. The ores of the last group are considered to be the most important in the district. It is also considered that the deposit is favourably placed with regard to other raw materials, e. g., limestone, magnesite and power. It has been estimated that 15 million tons of magnetite occur in the five bands of this hill.

Mysore

Iron ores occur in the Mysore State, particularly in the Bababudan Hills of the Kodur district having 58

1. Holland, T.H., The Iron Resources and Iron Industries of the Southern Districts, Madras Presidency, *Imp. Inst. Series of Handbooks of Commercial Products*, Calcutta, 1893.

to 64 per cent. of iron and with subsidiary deposits in the Shimoga district. The following analyses represent the percentage composition of the high, medium and low grade ores.

	High Grade	Medium Grade	Low Grade
Iron	68.24	58.66	53.85
Sulphur	0.038	0.038	0.03
Phosphorus	0.031	0.038	0.05
Manganese	0.10	0.13	trace
Silica	1.12	1.96	3.63
Alumina	2.36	3.60	9.42
Titanium dioxide	trace	trace	trace
Loss on ignition	5.23	8.87	10.61

In 1918 it was decided to start the Mysore Iron Works at Bhadravati and the smelting operations were started in 1923. The smelting is done with charcoal made from the wood of the neighbouring forests and wood alcohol, acetate of lime and wood tar are produced as by-products in the making of charcoal. The plant has a maximum capacity of 80 tons of pig iron per day.

Goa and Ratnagiri

Valuable resources of high grade iron ore occur at Goa and Ratnagiri. As these deposits are within the easy means of transport it is likely that they may be mined in future for export.

All these deposits occur in the Iron Ore series or the metamorphosed sedimentaries of the Dharwar period. The ore bodies are found in banded hematite quartzites. Being hard they build high steep ridges 1,500 feet or more above the surrounding plains. The

ore can be easily quarried in benches. It is transported in trucks to the works.

Progress of Industry :— In pre-war years the progress of the industry may be gauged by the fact that the production of steel ingots increased from 590,600 tons in 1932-33 to 1,070,400 tons in 1939-40. Monthly production has exceeded 100,000 tons since Steel Corporation of Bengal has commenced operations. The figures for the production of finished steel during the same period increased from 441,000 tons to 1,065,000 tons.

Exports :- In 1938 India exported 525,529 tons of iron ore and pig iron and 66,151 tons of steel. Exports of pig iron to the various countries during 1936 and 1937 are shown in the following table :-

Exported to	1936		1937	
	Tons	Rupees	Tons	Rupees
1. Japan	367,296	83,30,307	281,748	95,53,412
2. United Kingdom	160,571	35,49,020	215,801	77,13,868
3. U.S.A.	56,244	12,92,289	68,013	23,85,623
4. China	5,749	1,33,160	6,766	1,81,528
5. Other Countries	16,116	4,03,288	25,003	7,64,147
Total	605,976	1,37,08,064	597,331	2,05,98,578

The value of the exported steel nearly increased by about 50 per cent. and the value per ton increased from Rs. 22.6 in 1936 to Rs. 34.5 in 1937. Japan was the principal buyer before the War, while the United Kingdom ranked next.

Further Expansion :- The Government of India have decided to instal two units of 500,000 tons each. India should undertake the manufacture of machinery and other iron and steel goods required for further industrial development. The question of conservation of metallurgical coal has been referred to in its appropriate place. It is feared that in about 30-50 years the known deposits of metallurgical coal may be approaching exhaustion. In that case the iron and steel industry will have to find means to utilise other varieties of coal or will have to revert to electrosmelting.

Manganese Ore

The important producers of manganese ore are Russia, India, the Gold Coast, South Africa, Brazil, Cuba, Egypt, Czechoslovakia and Japan. The production of manganese ore is an important industry of India and she is the second leading producer of manganese ore, Russia being the first. However, when conditions are unsettled in Russia, India occupies the premier position.

India is responsible for about one-third of the world's output. The Central Provinces alone account for about 70 per cent. of India's production, the Balaghat, Nagpur and Bhandara districts representing the chief mining centres. Other important deposits are those of the Panch Mahals in Bombay, Vizagapatam in Madras, Singhbhum in Bihar, the States of Keonjhar, Bonai and Sandur (See Fig. 24).

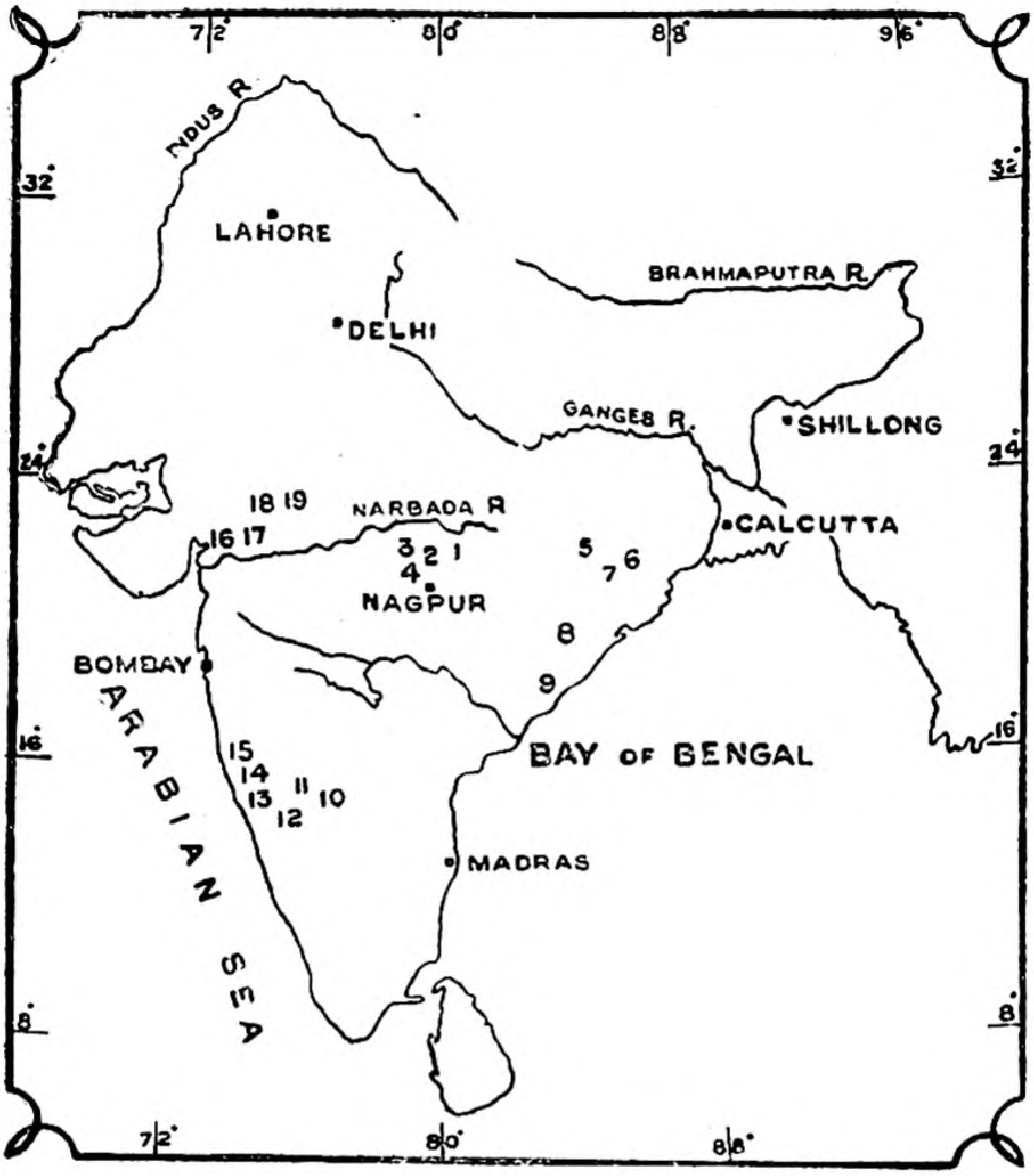

Fig. 24–Showing geographical distribution of manganese ore deposits.

The list of manganese ore deposits is as follows :—

1. Balaghat. 2. Bhandara. 3. Chhindwara. 4. Nagpur. 5. Gangpur. 6. Singhbhum and Keonjhar. 7. Bonai. 8. North Koraput. 9. Vizagapatam. 10. Sandur State. 11. Bellary. 12. Shimoga, Mysore. 13. North Kanara. 14. Dharwar and Ratnagiri. 15. Goa. 16. Narukot State. 17. Chota Udaipur. 18. Panch Mahal, Bombay. 19. Jhabua, Central India.

The manganese deposits of India have been classified as follows:—

(1) Manganiferous metamorphosed sediments associated with rocks of Dharwar age, which are styled as the Gondite series. In this case the manganiferous sediments have been converted into crystalline manganese ores, pyrolusite, psilomelane, braunite, etc. The ore occurs as lenses and bands which may be a mile or two in length. The ore bodies, being resistant to denudation, tend to form small hills as observed in the neighbourhood of Munsar, Kandri, etc. near Ramtek in the Nagpur district. These deposits occur in the Balaghat, Nagpur, Bhandara, Chhindwara and Seoni districts of the Central Provinces, the Panch Mahals in Bombay, Jhabua in Central India and Gangpur State.

(2) Manganiferous deposits associated with intrusive rocks. These deposits, forming the Kodurite series, occur in Vizagapatam district of Madras.

(3) As lateritoid replacements occurring on the outcrop of Dharwar rocks. These deposits occur in the Jubbulpore district of the Central Provinces, Singhbhum in Bihar, North Kanara and Ratnagiri in Bombay, Bellary and Sandur State in Madras, Chitaldrug, Shimoga and Tumkur in Mysore State.

(4) Manganese ore is also found associated with high and low level laterite deposits.

(5) Detrital Manganese Ore Deposits. In classifications, generally reproduced in most works on manganese ores of India, their mention is omitted. The author visited some of these deposits, particularly those of Munsar, Parsoda and Kandri in the district of

Nagpur in December, 1943 and a note on "The Detrital Manganese Ore Deposits in the Neighbourhood of Munsar and Parsoda Mines, Nagpur District, Central Provinces" was published in *Science and Culture*, vol. XI, 1945, pp. 503-504. These deposits supply quite an appreciable quantity of manganese ore, which is low in phosphorus and silica and this material, therefore, finds preference for metallurgical purposes and is used in admixture with manganese ore mined *in situ*. These deposits can be classified into two groups :–

(a) Detrital talus deposits which occur on the higher slopes.

(b) Detrital alluvial deposits. This ore material is of course partially water worn and the size of the ore is variable comprising both gravel and boulder deposits. The Munsar and Parsoda workings, their method of working and production have been described in the communication mentioned above and the interested reader is referred to it. It is noteworthy that these detrital workings contribute substantially towards the total production of manganese ore; sometimes it may be as much as about 50 per cent. of the total production of a mine. A reliable authority, Mr. C. A. Wellstead, Manager of the Munsar Mine informed the author that the total production of manganese ore from these detrital workings in the Central Provinces may amount to 25 per cent. of the total production of the manganese ore.

Extent of Ore Deposits :– It is noteworthy that manganese ore deposits, particularly those associated with the Gondite series, are of great extent. The Balaghat deposit is $1\frac{3}{4}$ miles in length. The Manegaon deposit

attains a length of $1\frac{1}{2}$ miles. The deposit extending through Jamrapani, Thirori and Ponia in the Balaghat district is known to run more or less continuously for a length of six miles. According to Dr. L.L. Fermor[1], these deposits are 45 to 50 feet in thickness, which owing to folding was earlier taken to be much greater. These ore-bodies extend to considerable depth, viz., 400 feet or even more.

Production :– In 1927 India produced a record output of 1,129,353 tons of manganese ore valued at £ 22,703,068. Since that time India suffered a catastrophic decline during the years 1932 and 1933. During 1932, 212,604 tons of ore valued at £ 140,022 were won, while in 1933, the production of 218, 307 tons was somewhat better, but the value dwindled to £ 123,171. The exact magnitude of the disaster, that befell the manganese industry, can only be realised from the fact that while the output was a little over one-fifth of the record output of 1927, the price realised was below 1/22 of that of the year 1927. During the slump period the manganese industry suffered the worst misfortune of all the important mineral industries of India. But since 1934 the industry has recovered itself with the consequence that although the output during 1937 was 1,051,594 tons, smaller than that of 1927, the value realised was over 50 per cent. greater than that of 1927.

The output and value of the manganese ore from 1927 onwards is shown below :–

1. *Rec. Geol. Surv. Ind.*, vol. LXX, 1936, p. 240
2. Since these are mainly export values, they are given in £. £1= Rs. 13/6/–.

Year	*Output in tons*	*Volue in £*
1927	1,129,353	2,703,068
1928	978,449	2,198,895
1929	994,279	1,571,030
1930	829,946	1,200,236
1931	537,844	726,954
1932	212,604	140,022
1933	218,307	123,171
1934	406,306	338,240
1935	641,483	768,630
1936	813,442	1,124,422
1937	1,051,594	3,229,554
1938	967,929	2,932,445

Prices:—Manganese is consumed mainly in the manufacture of steel, its demand and prices are, therefore, linked with the vicissitudes of the iron and steel industry dependent upon commercial requirements as also on the manufacture of munitions. The prices of the first grade ore per unit c. i. f. United Kingdom is shown below :—

1924	22.9 d
1929	14.9 d
1932	9.5 d
1934	10.5 d
1936	12.26 d
1937	22.5 d

It will be seen that prices steadily decreased from 1924 to 1932. This fact can be explained that during 1924–27 the World's production of manganese ore was much greater than the corresponding World's production of pig iron and steel. As noted already, man-

ganese ore is largely consumed in the manufacture of ferro-manganese and steel. The decline of the manufacture of steel during the years of slump in manganese industry, is given in the sequel :—

Year				
1929	...	...	...	122 million tons (peak production).
1931	...	...	...	68 million tons.
1932	...	...	...	42 " "
1933	...	...	...	56.4 " "
1934	...	...	...	68.0 " "
1935	...	...	...	82.3 " "
1936	...	...	...	103.0 " "
1937	...	...	...	111.9 " "

It would thus appear that the phenomenal fall in prices of Indian manganese, as noted above, was connected with the world depression of steel industry during 1930–33. It would be, therefore, obvious that this partial revival of the steel industry has been responsible for the higher prices of manganese ore, as shown above.

Competition :— Russia produces large quantities of manganese ore and is able to place them on the market at such rates which many producers in India cannot manage unless the railway freights are reduced to the pre-war (1914–18) tariffs. Of late the Gold Coast and the newly discovered deposits of high grade ore in the Cape Province of South Africa are also producing large quantity of the ore. This large production coupled with the phenomenal decline in the steel industry was responsible for the disaster to the manganese industry.

As stated above manganese is used in the smelting of pig iron and manufacture of ferro-manganese and steel. The total amount of manganese ore consumed in this industry was 60,219 tons in 1937.

The following table gives the output of manganese ore in India for the years 1936, 1937 and 1944.

Province or State	1936		1937		1944	
	Tons	£	Tons	£	Tons	£
Bihar						
Singhbhum	11,722	17,437	24,180	77,376	4,495	7,754
Bombay						
North Kanara			18,723	59,914		
Panch Mahals	28,994	43,129	41,041	131,331	22,515	38,838
Central Provinces						
Balaghat	313,933	498,368	399,532	1,353,414	129,731	238,921
Bhandara	134,710	213,852	153,230	519,066	56,272	103,634
Chhindwara	803	1,274	1,048	3,530	1,078	1,985
Nagpur	119,360	189,484	141,367	478,880	107,631	198,220
Eastern States Agency						
Bonai	15,921	15,324	13,856	35,217	21,691	25,487
Keonjhar	68,116	58,801	82,128	208,742	18,377	21,593
Patna State	..	..	...	...	733	861
Madras (including Madras States)						
Bellary	100	71	450	913	73	68
Kurnool	..	..	200	423	..	..
Sandur State	102,966	73,363	149,782	303,933	653	573
Vizagapatam	15,258	12,143	20,509	45,120	3,203	3,123
Mysore						
Chitaldrug	692	522	2,841	5,993	45	
Shimoga	769	580	2,207	4,644	234	82
Tumkur	98	74	500	1,058	26	
Orissa						
Koraput	...	..	..	..	4,000	3,700
Rajputana						
Udaipur	...	...	..	..	19	
Banswara	...	...	..	..	204	206
	8,13,442	11,24,422	10,51,594	32,29,554	370,980	645,045

Exports :–India exports very large quantities of manganese ore and the figures from 1933 to 1937 are as follows :–

Year			Tons	Value in £
1933	...	...	376,354	212,264
1934	...	...	507,878	473,678
1935	...	...	864,698	1,034,179
1936	...	....	742,547	1,026,200
1937	...	....	1,151,834	3,536,130

During certain years the amount exported exceeds the total output for the year, the excess including the stocks from the previous years. The ore is exported from the ports of Bombay, Calcutta, Vizagapatam and Marmagao and their share in tons is shown in the following table :–

Seaport				1936	1937
Bombay	..	..	..	92,832	130,837
Calcutta	..	..	..	250,216	316,767
Vizagapatam	..	..	..	290,775	533,585
Marmagao	..	..	..	188,524	170,645
			Total	822,347	1,151,834

It is noteworthy that the largest quantity of the ore is shipped from the new port of Vizagapatam which is the nearest outlet for the Central Provinces, Calcutta comes next.

Buyers :– The United Kingdom is the largest buyer of the manganese ore shipped from the Indian ports. France comes next and Japan is the third. The United States of America and Belgium are also important customers. The imports by these countries naturally are somewhat variable. The amount taken by each

country with the values during the years 1936 and 1937 is reproduced below :–

	1936		1937	
	Tons	Value in Rupees	Tons	Value in Rupees
United Kingdom ...	219,041	44,34,761	272,265	57,72,092
France ...	93,346	17,65,760	185,203	42,09,414
Japan ...	108,374	16,41,594	178,547	32,80,694
U. S. A. ...	109,102	20,97,958	143,102	29,07,982
Belgium ...	62,015	12,78,214	137,537	32,13,962
Germany ...	12,617	3,69,946	17,925	4,77,858
Netherlands ...	5,750	1,03,500	18,412	3,45,497
Italy ...	1,000	16,375	10,564	2,61,417
Other countries ...	22,578	4,32,602	17,624	3,70,150
Total	633,823	1,21,40,760	981,179	2,08,39,066

As noted in the Chapter on 'National Mineral Policy' also, it is stated in first issue of *Indian Minerals* that about "90 per cent. of India's production, roughly of the order of 700,000 – 1,000,000 tons annually is exported abroad. The continuous flow of this valuable national asset in the raw state to foreign countries is considered to be a serious defect of the mineral economy of this country today. Much of the ore shipped for ferro–manganese smelting abroad might be converted into ferro-manganese in the country." Perhaps the difficulty of high phosphorus content of average grade ore and of the coke required, could be overcome by electrosmelting.

Uses:—Over 60,000 tons of manganese ore are consumed in India's iron and steel industry. Steel containing about 11-14 per cent. of manganese is very hard and tough and can stand shocks and abrasion. Likewise other steels and manganese alloys are also manu-

factured. Besides manganese ore is also used in colouring and decolouring glass, in chemical industries, in the manufacture of dry batteries and disinfectants, viz, potassium and sodium permanganates. It is also used in glazes for ceramic industry.

Labour:—About 20,000 to 30,000 people find employment in the manganese ore industry. Manganese ore is won by quarrying as well as by underground mining. As noted above, the ore is also obtained from the detrital or alluvial workings in which female labour is employed. The work is largely carried on piece-work system which is financed by contractors working for large manganese concerns.

Mica

Many varieties of mica are known, but muscovite and phlogopite, which are transparent in thin plates, are chiefly used for commercial purposes. The chief provinces, where mica is produced, are Bihar, Madras and Ajmer-Merwara (See Fig. 25). In the province of Bihar, a belt of mica, which is sixty miles in length and 12 to 14 miles in breadth, is found. The belt runs in a general east-west direction and occupies parts of the districts of Gaya, Hazaribagh and Monghyr and a very great portion of India's output comes from this belt. The most important mines are situated near the Kodarma forests. All this mica is sent to Calcutta whence it is exported.

The mica belt of Nellore is sixty miles in length and 8 to 10 miles in breadth. Most of the mines are situated in the Rapur taluka, where the belt is the widest. Nellore mica is greenish in colour and is

easily distinguished from "Bengal-ruby" variety of Bihar. The mica from this belt is sent to Madras from where it is shipped for export.

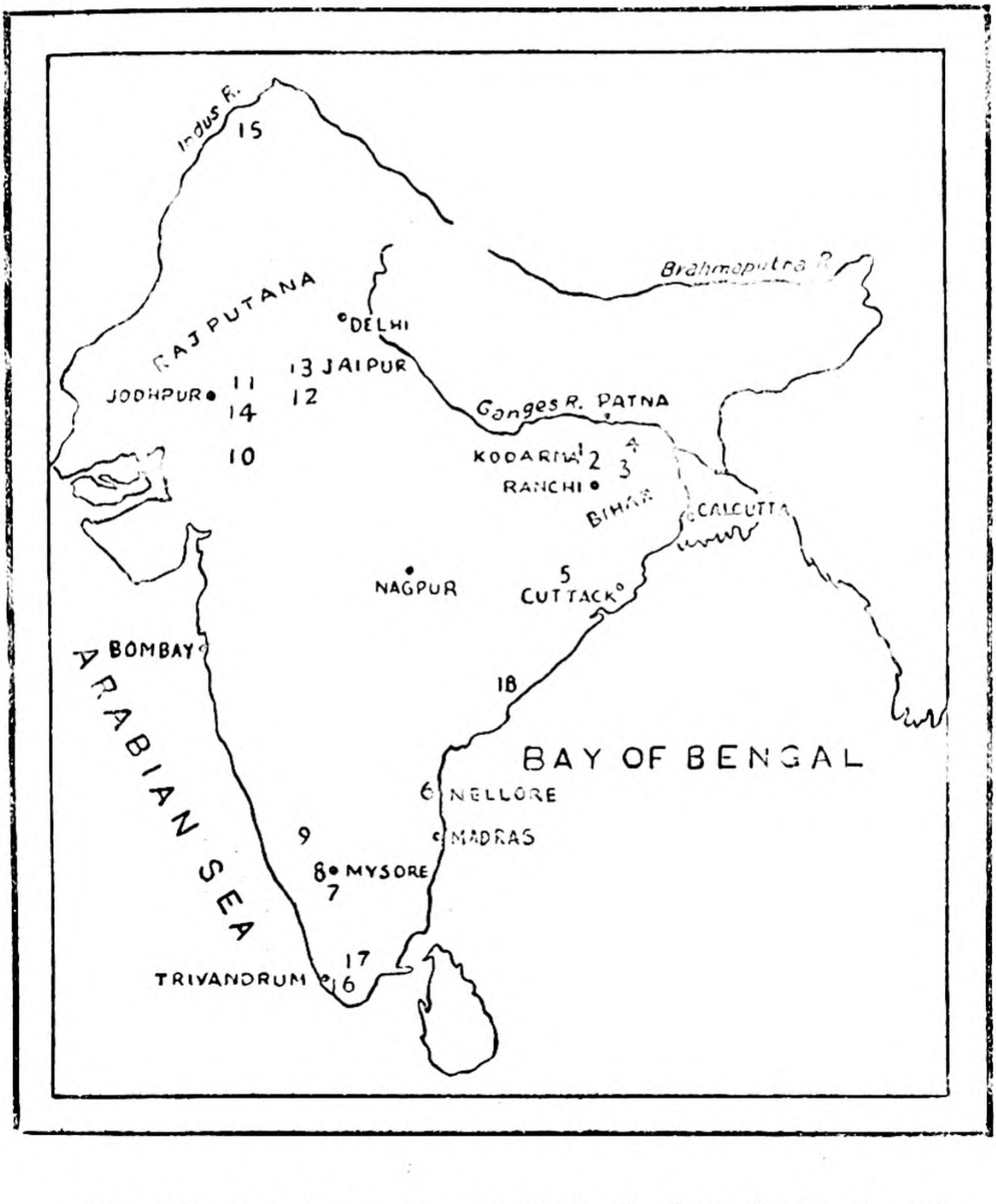

Fig. 25—Showing geographical distribution of mica deposits of India. Note their distribution in Bihar, Madras, Mysore, Travancore and Rajputana.

The list of mica-bearing localities is as follows:— 1. Kodarma. 2. Domchanch. 3. Giridih. 4. Chakal. These four localities are in Bihar. 5. Sambalpur district, Orissa. 6. Nellore. 7. Nilgiri. 8. Mysore district. 9. Hassan, Mysore State. 10. Udaipur. 11. Ajmer-Merwara. 12. Tonk. 13. Jaipur. 14. Shahpura, Rajputana. 15. Hazara district, N.W.F.P. The above are all muscovite-bearing localities. 16. Neyyoor, Travancore. 17. Punalur, Travancore. 18. Madugula, Madras. The last three localities are phologopite-bearing.

Sometimes, there is a little output from Gwalior also. The mica from Mysore and Rajputana is sent to Bombay for export.

Mica both in Bihar and Nellore occurs in pegmatites which are intrusive into the schists and gneissic granites of Archaean age. The pegmatitic veins are generally lenticular in shape and may have a maximum length of 1,500 feet with a maximum thickness of 100 feet. These pegmatitic veins are composed of quartz, felspar and mica. The associated accessory minerals include apatite, beryl, garnet and tourmaline. Mica occurs in rough crystals called blocks or books, those measuring 15 feet in length and 10 feet in thickness are known to occur.

It has been found that mica represents about 6 per cent. of the total rock excavated, while mica of saleable quality after dressing represents only one per cent.

The value of mica depends upon the size of books, perfection of cleavage, colour and clearness. Mica

may show internal structures which reduce its value. During the year 1937 the output of mica is shown in the following table :-

	Cwt.	Rupees
Bihar		
Hazaribagh	61,108	23,32,718
Gaya	20,055	7,32,788
Monghyr	3,467	91,603
Bhagalpur	922	6,646
Manbhum	246	7,718
Gwalior	12	not reported
Madras		
Nellore	15,647	6,48,075
Nilgiris	120	16,017
Travancore	67	2,150
Mysore	20	600
Rajputana		
Ajmer-Merwara	2,034	87,513
Jaipur State	780	24,993

The exports of mica with their values for the years 1936 and 1937 are tabulated below :-

1936	177,664 cwt.	Rs. 91,76,511
1937	297,343 „	Rs. 1,43,60,036

The chief consumers of mica with their percentage imports during the year 1937 are shown below :-

United States of America	....	62.3
United Kingdom	....	22.1
Germany	....	6.3

The quantity and value of mica including splittings exported from India during the year 1936 and 1937 are tabulated below :-

Countries	1936 Cwt.	1936 Value in Rupees	1937 Cwt.	1937 Value in Rupees
1. U. S. A.	93,080	27,90,668	185,143	43,67,799
2. United Kingdom	43,049	43,60,558	65,784	64,93,335
3. Germany	19,053	7,87,952	18,854	10,79,055
4. Japan	9,125	5,75,736	11,815	12,55,336
5. France	7,743	3,74,845	2,698	2,06,555
6. Other Countries	5,614	2,86,752	13,049	9,57,926
	177,664	91,76,511	297,343	143,60,006

India is the main producer of quality mica and of this 80 per cent. comes from Bihar and the remaining 20 per cent. from Nellore and other places. Bihar has been aptly styled as the custodian of the world's quality mica and it has been, therefore, suggested that these deposits should be worked as carefully as possible and all wastage should be scrupulously avoided.

The mica industry employs about 30,000 people daily, but during the recent years of the War, this figure must have been exceeded. The methods of mining for mica are primitive and consist in following along the vein from one book to another.

It is noteworthy that the dressing and splitting of mica is done by the aborigonal women of Bihar with great skill, so much so that every year some tons of foreign block mica are imported into India, which is exported after splitting. The usual thickness of the film is 1/1,000 inch. About 70-90 per cent. of the mica may be lost in splitting and trimming. The waste is used in grinding and sold as powder. The manu-

facture of 'micanite' sheets is carried out by hot pressing waste from the splittings with shellac as the binding agent.

The importance of this industry may be gauged by the fact that during the last War, mica was the only mineral transported by air to the United States of America. Mica is employed in a large number of industries, but is indispensable to electrical industry. Clear mica is resistant to heat and is used in making lamp chimneys, fronts of stoves and furnaces. Ground mica is used as a lubricant. Mica mining has indeed benefitted by the advancement in electrical engineering, motor transport, aeronautical science and radiotelegraphy.

CHAPTER XI

Mineral Resources (Contd.)

Bauxite Deposits

The ores of aluminium comprise two important minerals :–

(1) Diaspore having the composition of aluminium oxide (Al_2O_3) with one molecule of water.

(2) Bauxite having the composition of aluminium oxide (Al_2O_3) with about two molecules of water. However, it is generally believed that bauxite is an admixture of gibbsite (aluminium oxide with three molecules of water) and diaspore.

The great producers of bauxite are France, the United States of America, Hungary, British and Dutch Guiana. According to Dr. C. S. Fox[1] there are two main classes of ore : (1) the Mediterranean (*terra rossa*) type and (2) the Indian (lateritic) type. The former class includes bauxites of Spain, France, Italy, Yugoslavia and Rumania. These ores seldom contain more than 14 per cent. of combined water. In this connection it may be noted that the ore found in the Riasi district of Jammu Province is diaspore which contains only about 14 per cent. of water. If ores derived from limestone (and sandstone) are meant, then the ores of Katni belong to this class. According to the same author the bauxites of America, Africa, India and Australia belong to the latter class. He considers that they are of younger geological age, and contain 22 to 30 per cent. of combined water. Perhaps he still considers that these deposits are all derived from the Deccan Trap, while the present author has noted in the sequel

1. *Rec. Geol. Surv. Ind.* vol. LXX, 1936, p. 351.

that some of these deposits are derived from the Dharwar and the Vindhyan rocks.

Bauxite is a residual product of rock weathering in tropics. Large deposits of bauxite occur in Peninsular India as also in the Himalayan region. It was previously believed that all bauxite deposits of India were derived by the alteration of the Deccan trap, but the author has shown (*Journ. Sci. & Ind. Res.*, vol. 58, 1946, pp. 48-51) that the commercial deposits of bauxite in India (See Fig. 25) are also formed by the alteration of

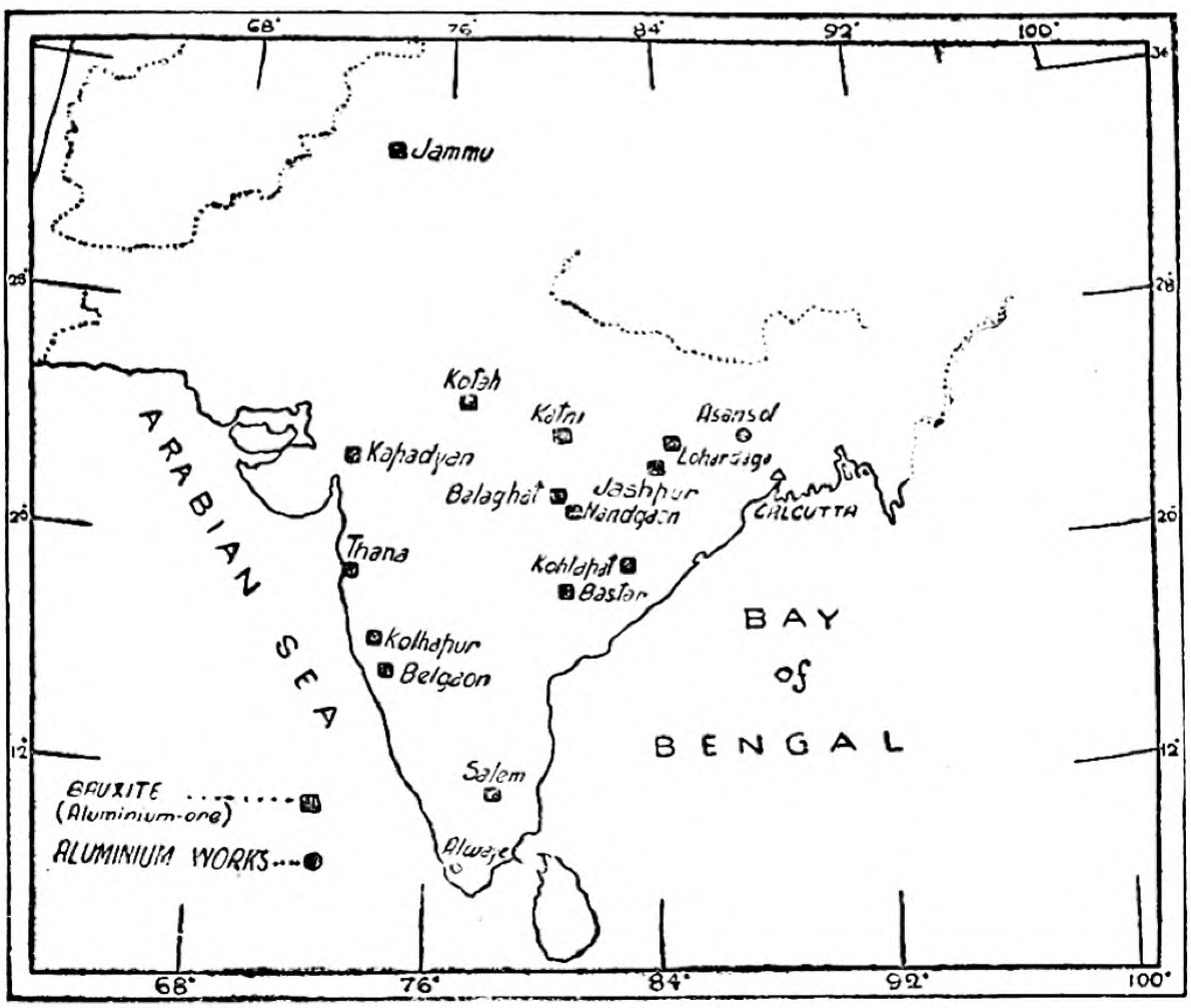

Fig. 25—Showing the geographical distribution of important bauxite deposits of India. Note the location of the Aluminium Reduction Works at Alwaye, Travancore and at Anupnagar near Asansol.

(1) granite-gneiss, (2) Vindhyan limestone, (3) Vindhyan sandstone and Great Limestone of Jurassic age. In Poonch these deposits are known to be associated with Sub-Nummulitic clays overlying the limestone of Jurassic age.

Deposits associated with the Deccan Trap

It may be observed that more than 200,000 square miles of Western India are covered by the Deccan Trap which generally forms flat-topped plateaux. These on weathering have altered to clay and bauxite in many places. Thus extensive deposits of bauxite derived from the alteration of the Deccan Trap occur in the Bombay Presidency, particularly in the districts of Belgaum, etc. It also occurs at Radhanagri in Kolhapur State, Bombay where an elongated plateau of the Deccan trap is capped with bauxite. In Kolhapur State bauxite is also known to occur in Dhangarvadi hill, 3,335 feet above sea level. The reserves are estimated at 8–10 million tons, while the alumina content varies from 55 to 60 per cent. Besides there are several other localities in this state, where bauxite is known to occur.

The bauxite of Kapadvanj deposit in Khaira district, Bombay has been worked which has been used by petroleum companies for purification of kerosene. Bauxite deposits also occur in the Thana district and those of I aumdongri, Bombassadongri and Tungar plateau deserve mention. It is also known to occur in Satara, Surat, Poona and Ratnagiri districts and also in Bhor, Rajpipla and Baroda States.

Rich deposits of bauxite occur in the Central

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Fig. 1—Showing a bauxite quarry, Bagru Plateau, near Lohardaga, Ranchi. District, Bihar. Stocks of bauxite are ready for transport to Lohardaga Railway Station. (*Photo: Vishwa Nath Chhibber*)

Fig. 2—Showing the Champi bauxite quarry, Bagru Plateau near Lohardaga, Ranchi District, Bihar. (*Photo: Vishwa Nath Chhibber*).

Provinces, particularly in the districts of Balaghat, Bilaspur, Mandla and Jubbulpore. Similar deposits occur in the Jashpur and Sirguja States of Central India.

Deposits associated with Granite-gneiss in the Ranchi District

Important deposits of bauxite occur in the Ranchi and the neighbouring Palamau district of Bihar. Here the bauxite is derived from the alteration of the granite-gneiss. It may be noted that the Deccan Trap is observed nowhere in these hills. It is generally observed that the granite-gneiss is first altered to kaolin which in turn alters to bauxite which is overlaid by laterite. In the neighbourhood of Lohardaga there is the plateau of Bagru where about half a million tons of bauxite has been proved. The maximum elevation of the plateau is 3,640 feet above sea level. But there are a number of other detached plateaux in this neighbourhood, e.g., Lalmattia Pat, Dudha Pat, Dhulua Pat, Garh Pat, Jogi Pat, etc. with about the same elevation as that of Bagru. The stages in the formation of bauxite and laterite have been described in the author's paper on "the Bauxite Deposit of the Bagru Plateau," *Trans. Ind. Cer. Soc.*, vol I, 1942, pp. 177-202. The rock is first changed to clay which subsequently alters to bauxite. Out of nine specimens of bauxite chemically analysed from the Bagru plateau four contained more than 60 per cent. of alumina, the maximum being 67 per cent. Four specimens yielded alumina between 52 and 60 per cent. Only one specimen contained alumina nearly 50 per cent. The average for the nine analyses is 58·18 per cent. It is noteworthy that the average alumina

content of numerous deposits in this region would approximate to that of the Bagru plateau as the author has studied in detail several bauxite deposits of this region. The total reserves of bauxite in this region are indeed very great.

Orissa

Bauxite occurs in Korla Pat in Kalahandi State. It occurs in association with laterite and its parent material is khondalite rock. According to M. S. Krishnan[1] a band of yellow-coloured bauxite of good quality containing nearly 62 per cent. of alumina and having a vertical thickness of 15 feet and a horizontal extent of 450 to 500 feet, occurs in laterite on the western flank of the Korlapat hill, east of Polengoodor village.

Madras

Recently bauxite has been found on six of the highest peaks of the Shevaroy hills, Salem district. These hills exhibit a characteristic flat-topped topography and the deposits are 30 to 40 feet in thickness. They are underlaid by lithomargic clay and undecomposed rock. The chemical composition of the average material would contain approximately 45 to 50 per cent. alumina, about 20 per cent. ferric oxide, 5 to 6 per cent. silica and 25 per cent. combined water. But it is suggested that in actual working it should be possible to eliminate more ferruginous material and select a grade containing over 54 per cent. of alumina. The total reserves of bauxite have been estimated at 6 to 7 million tons of which one-third is considered as a conservative estimate to be of good marketable quality.

1. *Rec. Geol. Surv. Ind.*, vol. LIX, 1926, p. 419.

Bauxite Deposits near Katni

In the neighbourhood of Katni, Jubbulpore District, some interesting deposits of clay and bauxite are observed. But here the parent-rock is the Vindhyan limestone presenting various shades of grey colour. The rock is usually well-bedded in thin layers. Overlying this limestone is usually a thick overburden of clay which is mainly whitish in colour. There is no doubt that this clay is of residiual origin. A visit to the quarry of the Associated Cement Co., Katni located on the Flagstaff Hill confirms the formation of bauxite from the whitish residual clay, and the former is definitely overlaid by laterite. No doubt, the parent-rock in this case is limestone, and by the leaching out of carbonate of lime, the residual hydrated alumina accumulates in the form of clay and has later changed into bauxite. It may be noted that bauxite deposits which have originated from limestone, occur in Italy, Yugoslavia and Austria-Hungary. Near Padarwara village three miles south of Katni railway station, sandstone forms the bed-rock which yields residual yellow clay which insensibly grades into bauxite and bauxite changes into laterite.

Diaspore Deposits of Jammu and Poonch (Kashmir)

The bauxite deposits near the village of Chakar in Jammu Province really represent diaspore which has been formed by the desilication of the upper layers of original kaolin. A gradual change is observed from kaolin to bauxite, while the intervening types are composed of aluminous and bauxitic clays. The ore

contains a high percentage of alumina varying from 60 to 70 per cent. with a low iron content which is generally less than 1 per cent. Large deposits of aluminium ore also occur near Sangar, a few miles E. N. E. of Chakar. Bauxite reserves of these deposits have been estimated at 1. 8 million tons.

According to D.N. Wadia,[1] a bed of bauxite one to three feet in thickness and almost free from iron occurs at the base of the Nummulitic series in the Kotli tahsil of Jammu Province. The chief occurrences are near the villages of Bandili, Dhanwan, Kamroti, Shishetar, Newal and Palana. It is believed that several hundred thousand tons of ore are available at the surface. Likewise bauxite deposits occur between Nanda Gali and Manhetaur in Poonch State, Kashmir. The reserves are estimated between 600,000 and 800,000 tons.

Thus any rock, which is capable of developing residual clay could be the actual or the potential source of bauxite or diaspore. Thus in India there are at least four well-marked belts of bauxite deposits. The first belt is connected with the Deccan Trap region of Peninsular India. The second belt is represented by the region of numerous detached plateaux formed of the granite-gneiss near Lohardaga in the Ranchi District of Bihar and elsewhere. The third belt is constituted by the group of bauxite deposits derived from the Vindhyan rocks in the neighbourhood of Katni, Jubbulpore District. The fourth belt is represented by the diaspore deposits occurring in the neighbourhood of Jammu, etc.

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1. *Rec. Geol. Surv. Ind.*, vol. LXIX, 1935, p. 24.

Estimated Reserves:—The estimated reserves of bauxite in India are 250,000,000 tons. Before the advent of metallurgical operations near Asansol and at Alupuram in Travancore State, the annual output of bauxite was only 10-15 thousand tons, which was chiefly employed in chemical and allied industries, but now the production is bound to increase with further development and expansion of the manufacture of alumina and aluminium.

Uses:—The manufacture of aluminium from bauxite has commenced in India and has been discussed in the sequel. Besides, it is also used in the manufacture of aluminous cement and alum and other salts which are used in dyeing and tanning. It also finds use as a filtering material in petroleum refineries for purifying and decolourising kerosene. It is also used in the preparation of refactories and abrasives. Some bauxites of India are particularly rich in titanium dioxide, which can be recovered as a by-product, which can be used in the manufacture of pigments.

Aluminium Industry of India

The aluminium industry of India commenced with small imports of aluminium sheets to be shaped into utensils, etc. by hand, and a little later utensil factories were established at two or three larger industrial centres. The first world war gave some impetus to the industry, when several manufacturing concerns in Calcutta, Bombay and Madras were actively manufacturing utensils, mess tins, water bottles, etc for the army. After the war not only the manufacturing of utensils expanded, but aluminium began to be utilised in the manufacture of industrial and tea garden equipment,

in the chemical and paint industries. Indian factories set up their branches in Burma, Malaya and Aden and the manufactured goods were exported to East Africa, Iraq, Palestine and Indo-China. By 1939, the year, which marked the outbreak of the second world war about 5,000 tons of aluminium were consumed in the aluminium manufacturing concerns on which a capital exceeding one crore had been invested, but the scope of the industry was still limited to mainly manufacturing aluminium utensils. However, the foundations for the actual production and fabrication of aluminium in India were laid about two or three years before the outbreak of the second world war, but the actual production of aluminium was considerably delayed by the war.

The fabrication stage consisted of rolling ingots into sheets which saw the installation of sheet rolling mills. About 1940 an up to date rolling mill had been established at Belur near Calcutta.

The aircraft industry, although in its infancy, consumes a large amount of sheet produced in India.

The first stage, as noted above, consists in the manufacture of aluminium from bauxite. It may be noted, however, that this manufacture represents an electro-metallurgical process and therefore an abundant supply of cheap power is the first requisite. This is well illustrated by the development of aluminium manufacturing industry of Canada which happens to be the world's largest producer of aluminium. Although there are no workable reserves of the ore available in Canada, yet the industry has developed solely because cheap hydro-

electric power is available. It may be noted that in India, both very large resources of electric power and the ore occur.

The ore, which could be suitably employed in the manufacture of aluminium, should contain 52 per cent. of alumina and 5 per cent. of silica. The occurrence of such large deposits has been noted above.

There are two stages in the smelting of aluminium from the ore. The first consists in the manufacture of alumina, a fine white crystalline powder containing 99.4 per cent. of aluminium oxide (Al_2O_3), while the second comprises the reduction of alumina into aluminium in an electric furnace. Aluminium was first produced in India in 1943 by *The Aluminium Production Company of India, Ltd.* at Alupuram in Travancore State which supplies the requisite hydroelectric power. During the war this concern was also engaged in the rolling of sheets, manufacture of aircraft parts, radio and field telephone equipment and various other articles including fuel tanks for fighter aircraft. Their production was restricted during the war by the amount of water power available, but the development of additional hydroelectric power will mean further increase in the output. The total projected output is aimed at 5,000 tons *per annum*.

An Alumina works is being installed at Muri junction in Bihar and operations for the manufacture of alumina were expected to commence by the end of 1946. Their initial capacity will be 10,000 tons, which will be ultimately raised to 40,000 tons *per annum*, and the bauxite will be obtained from the Ranchi district, Bihar.

Another important aluminium manufacturing concern is the *Aluminium Corporation of India Ltd.* near Asansol in Bengal. This concern, which uses thermal power, commenced production of alumina in May, 1944, while the actual reduction to aluminium took place in July, 1945. They obtain their bauxite from Katni and the neighbourhood in the Jubbulpore district, Central Provinces. Their production of the metal ingot is about 1,000 tons *per annum*. As an experiment, the rolling of sheet has also been done.

No doubt, the rolling of sheets received further stimulus during the second world war, but other developments after the war include the manufacture of aluminium cable, paints, tea chest linings, packaging, foil and even aluminium alloys, and firms are being established to manufacture them.

Future Scope

No doubt the aluminiun industry in India has a great future. Increasing industrialisation in general and the development of industries like transportation, automobile and aircraft construction, shipbuilding, etc. in particular will open new avenues for the expansion of the aluminium industry. It has been stated aptly that "India should be a strategic centre for export to a wide circle of surrounding countries".[1]

Gold

Gold mining in India dates from pre-historic times. During 1904–07 India occupied the seventh position among the gold-producing countries of the world, but in 1908 she was relegated to the eighth position until

1. *Journ. Sci. and Ind. Res.*, vol. I, 1943, p. 310.

1920 when she again regained her seventh position. From 1925–27 she again occupied the eighth position, but by 1933, as shown below, she had fallen to the tenth position. During 1933 the total output of gold for the whole of India, as shown below, represented 1.35 per cent. of the world's production.

Countries	Output in ounces for 1933*
1. Union of South Africa (Transvaal)	11,013,712
2. Canada	2,949,309
3. Russia	2,500,000
4. U.S.A.	2,152,755
5. Australia	825,930
6. Rhodesia (Northern & Southern)... ...	645,087
7. Mexico	637,727
8. Japan	433,800
9. Korea	370,000
10. India	336,100
11. Gold Coast	305,908
12. Colombia	298,243
13. Belgian Congo	283,081
14. Philippine Islands	282,836
15. New Zealand	161,755
16. Chile	147,052
17. Sweden	135,937
18. Rumania	127,147
19. New Guinea	121,913
20. Brazil	110,000
21. Other Countries	1,161,708
Total	25,000,000

* Based on the *Mineral Industry of the British Empire and Foreign Countries,* Imperial Institute, Statistical Summary, 1931-33.

Kolar Goldfield

It is noteworthy that almost the entire output of gold won in India comes from the Kolar goldfield of Mysore which is situated 125 miles west of Madras. It occurs on a plateau 2,800 feet above sea level. Kolar is one of the model mining towns in the world with modern amenities of life. The goldfield is situated in the Dharwar schists, which form a narrow belt for about 50 miles from north to south, but the productive portion of the lode is confined to only 4½ miles.

It has been found that in the early days shafts had been sunk in solid quartz to a depth of 300 feet. The modern enterprise commenced in the year 1871 when the first concession was obtained and a shaft was bored on the Ooregum Co.'s block. Between 1878 and 1882 several companies had been formed, but by 1884 most of them had exhausted their capital. In that year the Mysore Company found some rich deposit of gold in an old mine. Since then the history of the company has been a continued success. The various companies located from north to south are (i) Nundydroog, (ii) Ooregum, (iii) Champion Reef and (iv) Mysore Company. The Nundydroog Company acquired the Balaghat concern in 1932. Messrs John Taylor and Sons manage all these concerns.

Almost the whole of the noble metal has been won from the Champion Reef with an average thickness of three to four feet with north-south strike.

The depth reached in the Champion and Ooregum mines exceeds 8,500 feet below ground level or over 5,700 feet below sea level. They represent two of the deepest mines in the world. High temperature in these deep mines and rock bursts naturally add to the difficulties in mining and incease the cost of production.

Gold-bearing quartz occurs in separate ore shoots with intervening low grade or barren ground. If the individual gold shoots terminate, new ones appear to take their place. It is noteworthy that between the 44th and 65th levels measuring nearly a depth of 2,000 feet no gold was found, but at the latter level new ore shoot was met which continued to a depth of 1,000 feet. At the 75th level the gold-bearing quartz ore shoot is 46 inches in width.

Production:—During 1905 there was the maximum yield of 616,758 oz. of gold valued at Rs 42,373,457 from the Kolar goldfield. But later the output gradually fluctuated and declined and during 1930-39 the average annual output was about 330,000 oz. During 1940 the production was 285,929 oz. valued at Rs. 3,31,31,783, while in 1943 the output fell to 252,262 oz., but the value increased to Rs. 5,02,57,880. The production of gold for the decade ending with 1943 was 3,039,000 oz. representing one per cent. of the total world production excluding that of the U.S.S.R.

Hydroelectric Power:—The Kolar goldfield has been electrified by hydroelectric power produced from the Cauvery Falls. The first stage of this project, as described in a later chapter, was completed in 1902 and the power is carried by double transmission lines over

a distance of 92 miles. As a result of the Krishnarajasagara dam continuous supply of power even in years of deficient rainfall is possible. For further details a reference may be made to the Chapter on Hydroelectric Resources. A standby thermal plant is kept in readiness for essential purposes.

Hyderabad State

In the Raichur district of the Hyderabad State gold has been mined on a large scale at several places, e.g., at Hutti, Topuldodi and Wondalli. There are numerous old workings reaching a depth of 540 feet at Hutti in the Dharwar rocks occurring between the Tungabhadra and the Kistna rivers. The mining operations, which had commenced in 1903, however, ceased in 1920.

Dharwar Field

This goldfield occurs partly in the Dharwar district and partly in the Sangli State of Bombay Presidency, but reefs, however, are too poor to work and mining operations were stopped in 1911.

Anantpur District, Madras

Here gold occurs in several quartz veins which occur chiefly in the Dharwar schists extending for 32 miles in a north-south direction. After many vicissitudes operations ceased in 1927.

Likewise gold has been worked in the Wynaad district in the Nilgiris, but after many fluctuations mining operations have been abandoned.

Alluvial Gold

Alluvial or detrital gold is reported from mnay

places in India and the local inhabitants do some gold washing on some of the rivers of India. It is only a petty industry which brings a few annas after a day's work and is usually done to supplement other income. Some of the tributaries of the Brahmaputra in Assam, e.g., the Subansiri, and the Subarnarekha in the districts of Singhbhum and Manbhum in Chota Nagpur may be mentioned. Gold washing is also carried on in several districts of the Central Provinces, but the total annual output from the province is hardly 200 ounces.

Kashmir

Gold washing is also known in the Indus valley in the Gilgit and Baltistan Divisions of Jammu and Kashmir State. In 1929, for which the output figures are available, only 56.3 ounces were won.

Likewise gold washing is also reported from some of the rivers of the Punjab and the United Provinces.

The output of gold from India for 1936 and 1937 is shown below :—

	1936		1937	
	Oz.	*Value in Rs.*	*Oz.*	*Value in Rs.*
Bihar	82.0	5,004	26.0	1,645
Mysore	331,856.1	3,04,92,796	330,710.2	3,03,93,539
Punjab	7.0	512	5.8	537
United Provinces	1.1	97	1.9	150
Total	331,946.2	3,04,98,409	330,743.9	3,03,95,871

Copper

Copper is a 'key' metal and it also forms important alloys with other metals, e.g., brass (copper and zinc)

and bronze (copper and tin). The United States of America, Chile, Canada, Northern Rhodesia, Belgian Congo and Russia are the leading copper-producing countries of the world. The world's total annual production during the years 1929–38 averaged 1·5 million tons. Many centuries before the introduction of modern methods, copper was smelted in large quantities in several places in India, e.g., in Singhbhum in Bihar, in Rajputana, in Chota Nagpur and in Peninsular India and in Kulu, Garhwal, Nepal, Sikkim and Bhutan in the Outer Himalayas. The commonest ore of copper in India is copper pyrites which near the surface is altered to malachite and azurite.

Within recent years copper smelting has been revived by modern methods in the Singhbhum district of Bihar, and this industry, no doubt, is of great importance to India. Here a copper belt extends in a curve over a distance exceeding 80 miles commencing from the Bamini river near Duarparam through Kharsawan, Seraikela and Dalbhum to Bhairagora on the border of Mayurbhanj State. Here numerous old workings and slag heaps are to be seen. The important portion of this belt occurs between Rajdah and Badia. The copper ores of this belt are associated with tongues of granite which are intrusive into the schists. They occur as veins in granite and the neighbouring schists. At Rakha Mines, Mosabani and Dhobani they form well-developed lodes which may vary in thickness from one inch to two feet, the average being 5-7 inches.

Attempts to work these deposits by modern methods proved abortive until the Mosabani mines were deve-

loped. Since 1919 *the Indian Copper Corporation Ltd.* has been smelting with success. In 1930, a rolling mill for the manufacture of brass made of 68 per cent. of copper and 38 per cent. of zinc was installed. At the end of 1940 the ore reserves in the Mosabani mine were estimated at about one million tons containing an average of 2 per cent. of copper. Since 1933, copper ore has been obtained from Dhobani, etc. where a copper lode parallel to that of Mosabani is being developed. The ore reserves at Dhobani at the end of 1938 were estimated at 127,131 short tons with an average of 3.14 per cent. of copper.

The annual production capacity of the extended plant exceeds 6,500 tons, which is mostly converted into more than 9,000 tons of brass sheet.

Hazaribagh District, Bihar

Extensive old copper workings occur at Baragunde in the Hazaribagh district. The workings occur in quartzites, associated with gneiss and some schists. The copper content, however, is low and several attempts to reopen the mines during the last more than 80 years have proved unsuccessful.

Darjeeling District

Low grade copper ores have been smelted in the past by local people in several places in the Darjeeling district. Copper pyrites is disseminated in the slates and schists of the Daling series.

Sikkim

The most important copper deposits of Sikkim are those of (a) Bhotang and (b) Dikchu. Both these

deposits contain chalcopyrite. The Dikchu deposit occurs in mica schists and associated gneisses lying between the Daling series and the Sikkim gneisses. The lode is three feet in width and is traceable for 300 feet. It containes 6.14 per cent. of copper.

At Bhotang there are two parallel bands measuring three feet and 2½ feet in width respectively and are separated by about 10 feet of slates. The percentage of copper in this case is larger than in Dikchu deposit.

Copper deposits are also known to occur in the Kulu and Kangra valleys, in the Garhwal and the Almora districts of the Kumaun Himalayas, but the value of these deposits is not exactly known. They are also situated in difficult and almost inaccessible regions with no transport facilities.

Rajputana

The Singhana, Khetri and Babai mines of Jaipur State are almost continuous for 15 miles. They occur in slates and schists. The mines are deserted and are in a waterlogged condition, but it has been opined that the large low-grade ore occurs in sufficient quantity to warrant the drainage and reopening of the mines for further prospecting.

Future Possibility :—During the quinquennium 1929-33 an average annual consumption of copper and brass in India was of the value of Rs. 1,29,78,592 and Rs. 2,53,27,369 respectively, while the average annual production for copper and brass in India amounted to Rs. 67,15,742 and Rs. 95,33,723 respectively. The average annual consumption in India during 1934-38 was Rs. 1,10,32,017 in case of copper and Rs.

1,59,21,637 for brass, while India's production amounted to Rs. 17,07,117 of copper and Rs. 66,32,269 of brass. Thus it would seem that India's production meets only a fraction of her requirements. Thus there is a great scope for the expansion of copper and brass industry in India. It has been suggested that the old mines of Jaipur, Darjeeling and Sikkim could be developed. The copper belt of Singhbhum has not been fully prospected. Moreover, the sulphur from the smelting of copper ores in Singhbhum is not recovered.

Salt

Salt is obtained in several places in India by evaporating (a) the brine of the sea, (b) subsoil brine or brine from the lakes; (c) Rock salt occurs in the Salt Range both in the cis-Indus and trans-Indus regions where several salt mines are situated at different places. It may be noted that salt is mainly used in India for human consumption. Its utilisation for industrial purposes, e. g., for the manufacture of caustic soda, soda ash, etc. has just begun. The Alkali and Chemical Corporation of India Limited, (Khewra, or 18 Strand Road, Calcutta) are manufacturing some of these commodities at Khewra. Likewise caustic soda from salt is also being manufactured at Dalmianagar in Bihar. An important chemical industry has been established by Messrs.Tata Chemicals Ltd., Mithapur situated in Okhamandal, a district in the Baroda State on the westerly tip of Kathiawar. Tatas have acquired the Okha Salt Works, the first modern salt works of the kind in India, as salt is one of the primary raw materials for alkali industry. Soda ash, caustic soda and sodium bicarbonate are manufactured. The gaseous products

obtained by the electrolysis are utilised for the manufacture of bleaching powder, liquid chlorine and hydrochloric acid. The basic materials required for the manufacture of dye-stuffs, fertilizers, drugs, pharmaceuticals, glass, etc. are being produced for the first time in India.

The brine from the sea on the east and west coast of India produces nearly two-thirds of the salt produced in India, while the salt lakes in Rajputana supply about one-fifth and rock-salt deposits of the Salt Range and Kohat supply the remaining one-eighth. Salt is also manufactured at Aden, which along with salt from the Red Sea ports is imported to an extent of 300,000 to 400,000 tons for consumption in India.

The output for the important salt-producing regions for the years 1938 and 1944 is given below :–

	1938		1944	
Province	Quantity in tons	Value in Rs.	Quantity in tons	Value in Rs.
Bengal	267	3,595	2,778	5,15,283
Bombay	406,992	18,84,939	538,771	69,82,709
Gwalior*	183	9,711	56	4,356
Madras	453,954	31,00,561	508,220	1,09,71,812
Northern India	582,391	40,36,224	701,790	53,87,659
Sind	95,876	4,83,353	90,988	4,59,463
Bihar and U.P.	...	...	918	50,120
Orissa	...	...	19,855	2,26,358
Baluchistan	...	...	1,349	21,950
	1,539,663	9,518,383	1,864, 725	2,46,19,710

* Figures for 1944–45.

Bombay

In Bombay Presidency salt is obtained by the evaporation of the brine from the sea. There are salt factories at Dharasna and Chharvada on the eastern side of the Gulf of Cambay near Bulsar, which are worked departmentally. There are Government salt works within a radius of 30 miles of Bombay which are leased to manufacturers. There are other factories also which are worked by private enterprise. Near Port Okha in Kathiawar, the Okha Salt Works Ltd. are manufacturing fine white crushed salt from sea brine by solar evaporation. The working season naturally varies with the monsoons, but generally lasts from January to June.

The shallow brine wells on the Little Rann of Cutch supply 20 to 25 per cent. of the production of the province and there are works at Kharagoda and Udu operated by the Department. There is a similar manufacturing concern at Kuda which is operated by the Dharangadhra State and the manufacturing season is from November to April.

Only about 25 per cent. of the total production is consumed in the province, while the balance is exported to the Central Provinces and the Deccan.

Sind

In Sind the salt is obtained from two sources : first by the evaporation of sea water near Karachi at Maurypur Salt Works and secondly from natural crystallised brine deposits of Darwari and Saran in the Thar-Parkar district. In recent years the industry in

Si‥d has undergone considerable expansion from an output of 36,350 tons in 1929–30 to 116,384 tons in 1937.

Madras

In this Presidency the entire production of salt is obtained from sea brine and evaporation is affected by solar heat. Over 90 per cent. of salt in this province is produced by licensees; the Government produces only the remaining small fraction. The coast comprises a length of 1,600 miles and V. S. Swaminathan[1] has divided it into three groups, viz., (i) the northern extending from Ganjam to the Kistna district, (ii) the central stretching from the Kistna district to Chingleput and (iii) the southernmost from Chingleput extending as far west as the Udipi district in Malabar. During 1930, 68 factories were working in 48 salt manufacturing centres. The working season is variable. In the north it begins in January or February and lasts till June or July. Farther south commencing in March or April it ends in August or September. In extreme south salt can be manufactured until October or even November.

Bengal

The possibilities of manufacture of salt on a large scale in the Sunderbans have been examined and several companies are now engaged in the manufacture at various places in West and East Bengal, e.g., Midnapur, 24–Parganas and Chittagong.

Bengal imported a total of 15,700,000 maunds in

1. *Trans. Min. Geol. Inst. Ind.*, vol. XXV, 1930, p. 158.

1937-38 as compared to 14,409,400 maunds in the previous year. Calcutta imported nearly 14,500,000 maunds or 92.17 per cent. and Chittagong the balance of 1,200,000 or 7.83 per cent.

Rajputana

Sambhar:– There are a number of lakes of inland drainage in Rajputana, the Sambhar being the largest. Salt is manufactured from the brine of these lakes and the Sambhar including the *kyars* at Jhapog, Nawa and Gudha provides an annual production of about 250,000 tons *per annum*. According to Dr. H. B. Dunnicliff[1] it represents the single largest source of salt in India. It is situated at 1,200 feet above sea level. The Sambhar is fed by weak brine brought in by four seasonal rivers, viz., the Menda, the Rupnagar, the Kharian and the Khandel and these along with minor streams have a catchment area of some 2,000 square miles. The outlet is effaced by advancing deserts sands. At its highest level it covers an area of about 90 square miles with a depth of 2 feet which by March or April dwindles to a small central puddle. It has been shown that the salt resources of the Sambhar are confined to a saline silt which occupies an area of 80 to 90 square miles and has a depth of 60 to 70 feet in the centre. W. A. K. Christie has calculated that there are more than 55 million tons of salt in the upper 12 feet of this silt. During the hot weather, when the lake has dried up, the brine present in its clay bed rises to the surface by

1. The Salt Industry in Rajputana, *Journ. Sci. and Ind. Res.*, vol I, 1943, pp. 270-278. See also *The Salt Industry in India* By S. C. Agarwal (Govt. of India Press), 1937, pp. 48-49.

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capillary action and is there evaporated to dryness. The saline deposit from the bed of the lake is collected and refined. The origin of this salt is interesting. Holland and Christie[1] are of the opinion that the Sambhar salt is not only due to excessive evaporation, but is derived from the sea spray and fine salt powder carried by the strong prevailing winds which blow from the Rann of Cutch into Rajputana during summer. It is considered that this wind-borne salt is dissolved by the scanty rains and carried into the lakes. It was calculated by the above authors that the amount of salt thus added annually is about 1,30,000 tons. The Sambhar lake supplies 80-90 per cent. of Rajputana salt.

As stated on p. 65 of Part I of this work, there are other smaller temporary lakes in Rajputana, e. g., the Didwana, the Falodi, the Lonkara-Sur and the Kachor Rewassa. A brine-impregnated sub-soil is found all over the desert which extends to Sind. It was stated by Holland and Christie that "there may be many Sambhars concealed by the mantle of desert sand".

Didwana :–In a direct line Didwana is situated about 40 miles from Sambhar. It is an oval-shaped depression, 4 miles in length and 1½ miles in width. Only about 5 per cent. of the available area is being worked and the salt extracted is of somewhat poor quality. The production during the year 1942-43 amounted to about 14,000 tons of salt. Recently Dr. H. B. Dunnicliff[2] has reported the occurrence of rich deposits of anhydrous crystalline sodium sulphate locally called

1. *Rec. Geol. Surv. Ind.*, vol. 38, 1919, pp. 154-186.
2. *Op. Cit. Sup.*, pp. 276-277.

rohr at Didwana. It has been found that "there is sufficient sodium sulphate at Didwana to meet India's requirements for many years to come and also to provide the raw material for other valuable products."

Pachbadra :– The lake of Pachbadra is an oval-shaped depression, 7-8 miles in length and 3-7 miles in width. It is situated about 60 miles to the south-west of Jodhpur. The area is divided into three subdivisions, viz., Sambra, Hiragarh and Pusali and pits about 300 feet in length and 50 to 60 feet in breadth are dug to a depth generally 10-12 feet, although the size is somewhat variable. The process of concentration is slow and normally a pit is not opened up in less than 1½ to 2 years. Generally a pit, 300 feet in length and 50 feet in width would produce about 15,000 maunds of good quality salt. Thus the sub-soil brine is also used for the manufacture of salt and the average annual production during 1929–30 to 1933–34 was 35,800 tons with a maximum of 55,000 tons in 1929–30.

Rock Salt Deposits

As noted in the foregoing, about one-eighth of India's production used to be rock salt, but the deposits of the Punjab Salt Range and N. W. F. P. are now in Pakistan, while the salt deposits of Mandi State are in India. The deposits of the Punjab Salt Range have been worked from very old times. It is known that they were being worked during the Mogul and the Sikh rule. The author has paid visits to Khewra, Warchha and Kalabagh. There are a number of places, where salt is mined in the cis-Indus Salt Range, viz., Khewra,

Warchha, Katha, Nurpur, Malot and Kalabagh, but of all these Khewra represents the largest centre of supply. The Khewra salt mine has been mechanised and electrified and the salt is mined in a series of alternate chambers and pillars both by compressed air and electric drilling. Some of the older chambers are very big, measuring 700 feet in length and more than 250 feet in height. At Khewra there are four seams of rock salt intercalated in red ferruginous marl. They are noted below with their thickness:–

(1)	Buggy	at least 150 feet.
(2)	Sujowal	about 50 feet.
(3)	Upper Pharwala	70–80 feet.
(4)	Lower Pharwala	120 feet.

It may be observed that these seams are lenticular in shape. In 1930 Mr. E. R. Gee estimated the reserves of salt at Khewra at about 4 million tons.

At Warchha there are four seams styled as I, II, III and IV. No. I is the topmost and the first three seams are each about 8 feet in thickness, while No. IV is the main seam, which has a thickness of 15–20 feet. Here the mine is mechanised, but not electrified. The production from Warchha in 1944 was estimated at about 30,000 tons. About 1½ miles north-east of the Warchha mine a seam of salt over 75 feet in thickness has been proved in the Jansukh Valley.

At Kalabagh on the Indus, salt occurs again in lenticular seams and is quarried by manual labour.

N. W. F. P.

In N. W. F. P. rock salt occurs at Jatta, Bahadur

Khel, Kharak and Malghin in the Kohat district. The production at Jatta represents about two-thirds and the balance is largely provided by Bahadur Khel. At Bahadur Khel, rock salt is exposed for about 4 miles with a width varying from a quarter to half a mile, while the thickness is at least 1,000 feet. Salt is obtained by quarrying by manual labour and the reserves of the region are believed to be inexhaustible. This salt is consumed in the N. W. F. P. and is also exported to Afghanistan and the tribal area.

Mandi State

The rock salt mines, as noted above, occur in Mandi State. The salt is of dark purplish colour and contains earthy impurities to an extent of about 25 per cent. Occasionally pockets of pure crystalline salt are also found. The salt is quarried at two localities, viz., Drang and Guma, which are 14 miles apart.

Imports

The following table gives the quantity and value of imports of salt into India during the years 1937 and 1938.

	1937		1938	
	Tons	Value in Rupees	Tons	Value in Rupees
Germany	41,577	6,69,468	27,752	4,52,781
Aden and dependencies	295,879	52,80,684	216,883	26,97,967
Egypt	1,000	15,269	61,209	6,62,123
Other countries	530	97,489	26,111	3,86,867
Total	338,986	60,62,910	331,955	41,99,738

It may be observed that the second world war provided a great stimulus to the salt industry of India as imports during the war were eliminated from Germany and were greatly reduced from Aden and dependencies for want of shipping space. In 1942-43, the imports dwindled to 133,000 tons. In 1935 in India there was the minimum production of 1,084,000 tons. In 1940 the production was 1,644,000 tons, while in 1942 there was a record output of 1,890,000 tons.

CHAPTER XII

Mineral Resources (Contd.)

Precious Stones

India had a reputation for gem-stones from very early times. She had the proud privilege of having produced the best diamonds in the world, but her production has now considerably dwindled. However, Kashmir is noted for its sapphires, Rajputana for its emeralds and Central India for its diamonds. Besides a number of semi-precious stones also occur.

The beauty and value of a gem-stone are determined by its colour, lustre, play of colours and brilliancy. Cutting and polishing bring out these properties in a remarkable manner.

Diamonds

India, as noted above, has been famous for its diamonds and has produced some valuable stones like the Koh-i-Noor, the Great Moghul, the Regent or Pitt diamond. Diamonds in India are known to come from three areas. The southernmost region comprises the districts of Cuddapah, Anantpur, Bellary, Kurnool, Kistna and Godavari. Diamonds have been picked up from the surface, as also from the alluvial and *in situ* workings. Golconda, the ruins of which are to be seen a few miles from Hyderabad-Deccan, has become fabulous in connection with diamonds, but it was really a trading centre for diamonds picked up from the gravels of the rivers in Hyderabad and Madras.

The second area lies in the Mahanadi valley and

diamonds have been obtained from the alluvium of the Sambalpur district in Orissa and Chanda district in the Central Provinces.

The third area forms a belt having a length of 60 miles and a width of 10 miles with its centre at Panna. Diamonds are known to occur in the following States of Central India, viz., Panna, Charkhari, Bijawar, Ajaigarh, Kothi, Pathar, etc. The workings are in the conglomerate of the Vindhyan System and in the adjoining alluvium. The neighbourhood of Panna including Shahidan represents the richest part of this diamond field.

Production :—The production of diamonds from Central India for the years 1936 and 1937 is given below :–

	Carats	Value in Rupees
1936	1,457	62,171
1937	1,178	54,979

The Panna diamonds are generally of good quality being brilliant-white or blue-white in hue. The annual production, as noted above, is less than 1,500 carats. India produces a very small fraction of world's output of diamonds. The world's two important diamond-producing countries are South Africa and Brazil. Panna diamonds, however, often fetch higher prices weight per weight than South African diamonds.

India imports diamonds of the value of a crore of rupees *per annum*.

The diamond industry in India is stated to have

possibilities, provided the operations are carried out on a large scale and wasteful methods are eliminated.

Emeralds

Bubani Mines near Ajmer

Emerald, which is a green-coloured variety of beryl, is a rare gem-stone. Emeralds of good colour and without flaws are rare and command high prices.

There are two important emerald deposits in Rajputana. The first, known as the Bubani Emerald Mines, occurs about 4/5ths of a mile E.N.E. of the village of Muhami which is visible from the mines. The path from Muhami to Bubani passes a little south of the Mines. Near furlong post 10/2 on the Ajmer-Kishengarh road, a cart track takes direct to the mines. The author visited the mines last year, which are a recent find and there is no previous literature on them. The Mines are situated on a slightly elevated ground, slightly above 1,550 feet above sea level. These emerald mines are composed of a number of workings which comprise mainly the North-East Workings and the Southern Workings.

North-East Workings :– On the top there is generally a very small overburden in the form of soil with pieces of disintegrated rock. In these workings quartz-tourmaline-pegmatite rock with a N. E.–S. W. strike is exposed on the surface. In places, it becomes almost tourmaline schist with lenticles of quartz. Nearby biotite-tourmaline-schist is found, tourmaline occurring in the form of blades. Fine crystals of emerald occur in this rock and the gem-stone is found

in pockets. There is basal parting developed in the crystals along which they tend to break, but on exposure both emerald and its matrix tend to harden. A number of schists occur near the contact of the quartz-tourmaline-pegmatite, but biotite-schist, biotite-talcose schist and quartz-tourmaline-schist predominate. The maximum depth of these workings in June, 1947 was 30 feet. It may be noted that yellowish or colourless beryl is also associated with tourmaline rock, veins of which occur in the schists. Likewise yellowish or colourless beryl occurs in crystallised tourmaline-quartz rock. It may be noted that tourmaline and light green beryl (emerald) are seen intergrown. Tourmaline crystals occur as inclusions in beryl. Likewise inclusions of biotite in beryl are common; sometimes the two are almost intergrown.

Sometimes emerald crystals are coloured about the surface only, while in other cases they are only partially coloured apparently due to the partial absorption of the tint from the exterior. Crystals of emerald occur in quartz, sometimes several of them in quartz-biotite-rock.

Southern Workings :- Workings for emerald towards the south of the North-East Workings, described above, have been styled as the Southern Workings. Conditions, as observed in these workings, are similar to those noted above. A shaft 33 feet in depth had been sunk in these workings and emeralds continued to that depth. A drive from the shaft had been sunk to north-east and emeralds were found in the drive also.

A General Section in the Mines :— The following section was observed in the emerald mines. On the top there is an overburden of red earth, about a foot in thickness. In this small pieces of quartz occur, but no calcareous concretions. It is underlaid by white material which contains calcareous concretions resembling *kankar*. The thickness of the concretionary layer is variable. The size of calcareous concretions varies from a shot to a few inches in size. Below this occurs the decomposed rock.

Detrital Workings :– The overburden has a maximum thickness of two feet although in places it may be only a foot in thickness. The detrital material, which is composed of pieces of quartz, tourmaline, quartz-tourmaline-rock, biotite-schist, talc schist, and beryl, is embedded in red earth. This is collected and sieved. The red earth is thus sieved through, while the coarse material is washed in a water tub and small pieces of emerald are collected.

The author was informed that in the beginning large pieces of emerald were found in this detrital material and the underlying decomposed rock. The quality of these emeralds was superior to that of the emeralds mined *in situ*. The emeralds in the overburden have not apparently undergone much transport as they are somewhat angular in shape.

Dumps are also searched for emeralds by small boys. Rocks of the dumps are broken into small and pieces searched for emeralds. Material thus broken is passed through sieves and washed and emeralds are picked.

Emerald Mines of Kaliguman Area, Udaipur State

The second emerald deposits occur about one mile E. N. E. by N. of the village of Kaliguman. The railway terminus of these mines is Charbhuja Road on the meter gauge Udaipur-Chittorgarh Railway. There is only an unmetalled road to the mines which are about 13 miles from the railway station. These mines are located in a small patch on map-sheet 45 G/1 as Mewar-Merwara placed under the jurisdiction of Ajmer-Merwara. H. Crookshank has published a brief popular account of the mines under the title of "Emeralds in Mewar" in the first issue of *Indian Minerals*, pp. 28–30. The author visited these mines in June, 1947.

The mines are situated slightly below 2,200 feet above sea level. The highest workings are situated in the Kabra hill which forms a conspicuous landmark in the country.

The main mines are situated in a low ground, almost in a valley. On the east low granitic hills occur, while on the west and north-west higher hills composed of serpentinised peridotites occur. The guest house of the Company and the Morcha building are located on these rocks which are very highly altered and almost changed into serpentine which has altered further into talc. In places veins of asbestos are seen running into the rock.

About 100 yards N. N. W. of the Morcha building, hornblende schist is observed. This has only a small thickness and is succeeded on the west by granite

gneiss which almost assumes a schistose appearance. It occupies also an extensive area to the east. There are injections of pegmatite veins and even lenticles of quartz in the granite-gneiss. Pegmatites also occur in the hornblende schist. Sometimes biotite is also associated with these pegmatites and in places this mineral is concentrated with which emeralds are associated. Sometimes tourmaline is also associated with these pegmatites. In others both tourmaline and biotite may be present.

It is the biotite-rock in which emeralds are generally found to occur. It forms a kind of dyke which in places sends off offshoots, practically with a horizontal disposition. The thickness and breadth of the biotite-rock is variable. At Kabra its breadth is more than 150 feet with outcrop of pegmatite rock in places. Sometimes this rock is highly contorted and crystals of emerald are found embedded in it. At least three veins of biotite-rock could be observed :–

(1) Main Mine vein.

(2) Upper Bagmara-Kabra vein occurring on the eastern slopes of the Bagmara-Kabra hills.

(3) Vein near the western margin of the Kabra hill.

Emeralds, besides occurring commonly in biotite-rock, also occur in other rocks. Blocks of biotite-rock are broken and a search is made for emeralds. Emeralds, sometimes freshly recovered, are somewhat friable, but they harden on exposure. Sometimes two, three or even four crystals may be seen showing para-

llel growth. The size of the gem-stone varies from a tiny grain to more than an inch; occasionally a crystal may be several inches in size.

Main Emerald Mines :– Originally the main Emerald Mines were worked in the form of a quarry as it is being done at present in the Bagmara and Kabra workings but later they were converted into underground mines, which were about 45 feet in depth in June, 1947. Pumps for de-watering the mines have been installed. A number of shafts, e. g., C, D, E, F and H have been sunk. It may be observed, that emeralds are not uniformally distributed in the biotite-rock, but occur in pockets only.

Bagmara Workings :–The emerald-bearing biotite-rock follows a uniform strike for a distance exceeding 500 feet, but a little beyond shaft E, the vein ascends the eastern slopes of the Bagmara hill. The biotite vein with associated tourmaline with a width of 65-70 feet is entirely in the peridotite-rock and there are off-shoots from the main biotite vein and emeralds, as elsewhere, occur in pockets.

It may be noted that the Bagmara-Kabra workings, which occur on the same strike, extend over a distance of 600-700 feet.

The value of the emeralds is determined by its green colour, translucency and freedom from flaws. A good emerald is as costly as a ruby and more expensive than a diamond. The price of a good emerald may be as much as Rs. 2,000 per carat.

Aquamarine

Aquamarine is a transparent variety of beryl with a blue to sea-green colour. It was formerly won from the Shigar valley of Kashmir. These aquamarines are reported to be of large size with a pale delicate tint and a remarkable clearness.

Sapphire

Sapphire is a transparent variety of corundum, the common colour being blue. In Kashmir State, sapphires occur at Soomjam in the Padar district. The mines occur at an elevation of 14,950 feet above sea level on the south side of the lofty hill ranges. The gem-stone is associated with granite, other igneous intrusives or pegmatites. Associated with these sapphires, pale rubies, aquamarine, rubellite, green tourmaline, garnet and serpentine also occur. The colour of the sapphires varies from light blue to deep sky blue. The sapphires of Kashmir are very popular and fetch high prices. The area, however, is inaccessible for a greater part of the year and the production has varied a great deal.

Refractory Materials

With the development of industry there has been a great demand for refractory materials which are used in furnace linings, etc. In India various kinds of these materials are available. Important works have been established which are engaged in the manufacture of fire clay and silica bricks to meet the internal demand. Below are described briefly the occurrences of some of the important refractory materials in India.

Magnesite

The most important locality for magnesite is the 'Chalk Hills' which occur near Salem in Southern India. The mineral occurs as veins and patches in serpentinised rock which cover an area of 4½ square miles. It forms hillocks, 140 feet above the level of the surrounding plain and the mineral can be extracted easily by open quarrying. Reserves of the mineral in these hills are reported to be practically unlimited and the material is excellent, percentage of magnesium carbonate ranging from 96 to 99.

The Magnesite Syndicate Limited have been responsible for developing the magnesite industry of Salem. They have now seven kilns for the calcination of the crude magnesite. The mineral is treated on the spot to produce caustic magnesia by heating to a temperature of about 800° C and dead-burnt magnesia at about 1,700° C. In 1942, their monthly production of calcined and refractory magnesite was about 1,600 tons, representing 3,500 tons of the raw material. Of course the industry received considerable impetus during the last war. This production is capable of considerable further expansion as the magnesite deposits of the Syndicate are very large.

A large bulk of the material is exported from Madras and Cochin to England. A great part of the remainder is sent to Tata Iron and Steel Co., Limited and to Messrs Burn and Company's potteries at Raniganj for the manufacture of magnesite bricks for use in the steel works.

Magnesite Deposits, Mysore:–The only other deposits, which have been exploited, are in Mysore State. They occur at Dod Kanya and Dod Katur half-way between Nanjangud and Mysore City. The mode of occurrence of magnesite is the same as at Salem and total reserves of workable magnesite are estimated at several hundred thousand tons. The deposit has been worked for a number of years and the powdered mineral is sent to Messrs Tata Iron and Steel Works for the manufacture of magnesite bricks.

The output of magnesite in India for the years 1937 and 1938 with its value in rupees is given below :—

	1937		1938	
	Tons	Value	Tons	Value
Salem	23,782	1,40,708	23,052	1,34,876
Mysore	2,384	23,230	2,559	25,717
Total	26,166	1,63,938	24,611	1,60,593

Uses:– Magnesite finds many uses, the most important being as a refractory material in steel industry. Bricks made of dead-burnt magnesia are used for the purpose, and it may be noted that the bricks made in India have proved superior to Austrian bricks. It is also used in the manufacture of liquid carbon dioxide. Caustic magnesia is employed in the manufacture of 'Sorel' cement to make artificial stone for various pur-

poses. Magnesite is also the source of metal magnesium for manufacturing magnesium alloys, which combine great mechanical strength with lightness and rigidity indispensable for aeroplane industry.

Future Possibilities:—There is a great scope for the expansion of this industry. Dr. L. L. Fermor has expressed the opinion that there is a considerable scope for developing the industry of making artificial stone in India, particularly for flooring, making tiles, partitions, grindstones for rice mills, etc. As noted above, the manufacture of magnesium can also be established in India. Cheap hydroelectric power is available both in Salem and Madras and this along with cheap magnesite should prove very favourable for the economic production of magnesium. Furthermore, bauxite deposits have also been found in the same neighbourhood which should provide an excellent opportunity for the manufacture of magnesium-aluminium alloys.

Sillimanite

Both sillimanite and kyanite find extensive use as valuable refractories in ceramic, glass and electrical industries. Two occurrences of sillimanite are known in India : (i) Nongstoin State, Assam and (ii) Pipra in Rewa State, Central India.

The sillimanite deposit near Sona Pahar in Assam is associated with corundum and lies in the Khasi plateau, about 3,000 feet above the sea-level. These deposits are associated with cordierite-biotite-quartz-microcline-gneiss and schist containing sillimanite and

quartz. Most of the deposits are composed of massive sillimanite with a little corundum. One or two deposits are almost wholly composed of corundum, while many are formed of sillimanite alone. Thirteen different deposits are known which lie in a belt, about three miles in length and one mile in width. The rock is only slightly impure and the impurities comprise mainly rutile, a very little biotite and some iron ore. According to Dr. J. A. Dunn, the total minimum reserves down to a depth of 10 feet are 83,000 tons, while he considers that the actual amount may be considerably more. The deposits are, however, not easily accessible and transport charges to the Brahmaputra river would be quite high.

The second deposit of corundum-sillimanite is in the Rewa State of Central India. It occurs near the village of Pipra, which lies in the extreme south-east of that State. Other associated rocks with the deposit comprise sillimanite-schists and pyroxene-bearing rocks. The bed of corundum is about 70 yards in width and has a length of half a mile. On the basis of an average depth of 30 feet, the estimated reserves of corundum available represent 1 lakh tons. The reserves of good sillimanite are of the same order, but, however, impure material is intimately associated, thus making the extraction of good material difficult. This deposit also suffers from the same disadvantage of being situated in the interior of the country with poor communications.

Small deposits of sillimanite and corundum also occur in the Bhandara district of the Central Provinces. In Travancore it occurs as a sand.

Uses:– It is now known that mullite is an important material in the aluminous refractories and it can be derived both from kyanite and sillimanite. Kyanite expands on heating and, therefore, it has to be used after heating in kilns, while sillimanite can be used in its natural condition. Mullite, manufactured from either kyanite or sillimanite has great application in the ceramic industry. It is employed in the manufacture of electric porcelains which are characterised by their great strength, toughness and very low electrical conductivity. It is also used in making sparking plugs. It is finding an extensive use as a refractory material.

Kyanite

Massive kyanite is found only in Bihar. In the Singhbhum district of Bihar, kyanite-rock along with the associated kyanite-quartz-rock occurs in places forming a belt nearly 70 miles in length extending from Lapsu Baru to the Kharsawan and Seraikela States. It then turns south-east through Dalbhum almost to the border of the Mayurbhanj State. It is noteworthy that these deposits have a strike parallel to that of the copper belt and occur on the hanging wall side of the copper lodes.

The chief rock of the belt is muscovite-schist, but not infrequently hornblende-schist is also associated. The former contains large crystals of straurolite and garnet. The massive kyanite of commercial importance occurs in kyanite-quartz-rock or granulite.

Lapsu Baru in the Kharsawan State is an important locality where large outcrops of kyanite-rock occur as

segregations in the more acidic kyanite-quartz-rock. Some considerable deposits are composed of pure kyanite-rock. It is massive and has a medium to coarse-grained texture. It has a radiating columnar habit and some of the bladed crystals are more than a foot in length. It is surmised that these coarse crystals indicate that the deposit is of contact metamorphic origin. Rutile, which is often abundant, is the only other constituent. Fine corundum occurs only occasionally.

Other localities, where massive kyanite is found in commercial quantities in this belt, are (i) Ghagidih, (ii) Rakha Mines, (iii) Badia Bakra and (iv) Kanyaluka. The following figures give the minimum reserves of the kyanite-rock as estimated by Dr. J. A. Dunn up to a depth of 3 feet :-

Lapsu Baru	.. ..	214,000 tons
Ghagidih	.. ..	20,000 ,,
Badia Bakra	.. ..	10,000 ,,
Kanyaluka	.. ..	8,000 ,,

Massive kyanite of poor quality and associated with corundum occurs at Rengadih in the Manbhum district.

Chromite

Chromite, which is an oxide of chromium and iron, is mined in Singhbhum, Mysore and Baluchistan. The mineral is found as segregations in rocks which have now been largely altered to serpentine.

Singhbhum :– In Singhbhum chromite-bearing serpentinised peridotites occur near Jojuhatu west of

Chaibasa in three separate hills known as Kinsi Buru, Kitta Buru, Chitung Buro-Roru Buru, the last being the most important. The ore occurs in the form of veins which are lenticular in shape. Their length is 100 feet with a thickness up to three feet. The largest producers in Singhbhum are the Singhbhum Chromite Co. , Ltd. which can raise annually 8-10,000 tons of ore of different grades.

Chromite is also being raised in small quantities in Saraikela State of Orissa.

Mysore State :- Chromite also occurs in Mysore State in the districts of Mysore, Hassan, Shimoga, Kadur and Chitaldrug, the first two being the chief producing districts. In the Mysore district the ore occurs mainly between Mysore and Nanjangud, which occurs in the form of veins, lenses and segregated patches in altered peridotites, etc.

In the Hassan district the ore occurs in lenticular deposits. In 1918 it was estimated that the reserves of chromite in Hassan district were nearly 500,000 tons.

In Mysore production commenced in 1907, when 11,029 tons were exploited. The maximum production was in 1927, when an output of 40,121 tons was recorded. The ore is exported from the Portuguese port of Marmagao.

Bombay :- Chromite is also known to occur near Kaukauli in the Ratnagiri district on the river Janauli and near Vagda in Savantvadi State. The reserves of both these deposits have been estimated at 67,000 tons.

Baluchistan :- E. Vredenburg in 1901 was the first

to locate the occurrence of chrome-ore near Khanozai above the Upper Pishin Valley and near Hindubagh in the Upper Zhob Valley in Baluchistan. About 2 miles east of Khanozai, a segregation of almost pure chromite, about 400 feet long and 5 feet broad was located. Dr. L. L. Fermor in 1916 made a comprehensive study of these deposits. High grade chromite occurs as veins and irregular segregations in serpentinised peridotites.

Chromite has also been found near Fort Sandeman, but the quality is only second grade.

Production in this area commenced in 1903 and the maximum output of 27,209 tons was recorded in 1937. The chromite from Baluchistan is of high grade quality and is exported from Karachi lying at a distance of 600 miles from the deposits.

The output of chromite in 1938 and 1939 together with its value in rupees is given below :—

	1938		1939	
	Tons	Value	Tons	Value
Baluchistan	21,892	3,26,014	13,952	2,07,430
Bihar	5,194	99,928	4,476	1,01,218
Saraikela	94	940		
Mysore State	16,969	2,55,620	30,708	3,26,863
Total	44,149	6,82,502	49,136	6,35,511

Uses :- Chromite finds a number of applications in metallurgical industry, chemical industry and as a refractory material. Alloys of iron, nickel or cobalt with chromium are noted for their strength, toughness,

hardness, resistance to chemical corrosion and high electrical resistance. Alloys of chromium are used for high speed tools in munition works and in the manufacture of aeroplane engines. As a refractory material, chromite is used for lining steel furnaces in the form of blocks, bricks or cement. In India chromite bricks are manufactured by Tata Iron and Steel Co., Ltd and Burn and Co., Ltd, Raniganj. In chemical industry, chromates, bichromates, chrome-alum, various pigments etc. are manufactured. These chemicals find important use in tanning leather, dyeing textiles and paint industries.

Internal Consumption and Export :- Some of the ore is consumed as a refractory material in the steel works of India, while the remainder is exported to the United Kingdom, the United States of America and Germany.

Conclusion :- In the first issue of *Indian Minerals*, p. 7 it is stated that "the greater part of the production of chromite is exported and its sole indigenous use has been for the manufacture of refractory bricks rather than of chromium metal. As India's reserves are said to be somewhat limited in respect of high grade ores, it is right that future planning should be directed to chrome-ores mainly for the purpose of extracting the metal and manufacture of chrome-alloys".

Fire Clay

Fire clay is the name given to the more refractory clays. Several excellent deposits of this material occur associated with the coal measures of India, generally as an under-clay. Some of the Gondawana clays found outside the coalfields, e.g., those of the Jubbulpore

district have proved exceedingly refractory and have been utilised for a long time. The fire-bricks made out of the Indian fire clays have proved equal to the best imported from abroad and have gradually supplanted them.

Central Provinces

As noted already, fire clay occurs in most of the coalfields of this province. It forms a bed 11 feet 3 inches in thickness above Seam No. 2 at the Warora Colliery in the Chanda district.

Jubbulpore Deposits :– A very important deposit of fire clay occurs in the Chui hill and the adjoining area near the city of Jubbulpore. The author had the opportunity of investigating these deposits more than once. The clay occurs in the Jabalpur (Jubbulpore) group belonging to the Upper Gondwana age. The lower portion of the series is composed of sand-rock of variegated colour which on washing is used in the manufacture of refractory bricks, etc. Overlying these sands occurs an excellent and extensive deposit of fire clay, more than 5 feet in thickness. This fire clay is both whitish and dark grey in colour and the latter has some carbonaceous material associated with it. Samples subjected to white heat for an hour remained infusible and intensily hard.

Messrs Burn and Company established their pottery works at Jubbulpore in 1890 and apart from manufacturing fire-bricks they produce a host of other useful articles, e. g. , drain pipes, roofing and flooring tiles, jars, etc.

Fire Clay Deposit of Perfect Pottery :– The quarry of the Perfect Pottery is situated in a hillock, about 6 miles south-west of Jubbulpore railway station. To the east of this hillock there is the Deccan Trap area, while to the west lies the Madan Mahal granite. The quarry is about 2 miles north of Gwari Ghat railway station on the meter gauge line of B. N. Ry. This fire clay apparently belongs to the same age as that of the Chui hill.

Fire Clay Deposit of Bhaganwara :– The village of Bhaganwara is situated at a distance of 5½ miles from Sleemnabad Road railway station on the Katni-Jubbulpore section. The fire clay deposit occurs at a distance of about half a mile to the north-west of the village. Generally on the top there is a thin covering of the soil and the fire clay is generally whitish in colour which is fine-grained and compact and appears to have a good thickness. It was locally alleged that a well sunk to a depth of 80 feet could not touch the base of the deposit. It is noteworthy that there is no percolation of water in the deep workings. The author visited this deposit in the beginning of 1945 and the workings were seen to extend for about a furlong in W. N. W.-E.S.E. direction with about a similar width.

But the extent of the clay deposit is much larger. It occurs both in the jurisdiction of Bhaganwara and Dhuri villages. The latter workings supplied clay previously to Messrs Burn and Co. of Jubbulpore. However, these workings were lying inactive at the time of the author's visit.

The clay apparently belongs to the group of Upper

Gondwana clays and is to be correlated to the fire clay deposit of Jubbulpore and the neighbourhood.

Hoshangabad District :– A seam of Jabalpur (Jubbulpore) clay, about 6 feet in thickness, is quarried 3 miles south–east of Bagra. Red Denwa clay is mixed with it to improve its refractory character.

Narsinghpur District:–Fire clay occurs in several localities in lenticular deposits having a thickness up to 10 feet on the south of the Narbada, especially in the Bachai reserved forest and near Saonri. The deposits occur about 10 miles by road from the G.I.P. main line.

Rewa State

Fire clays occur in workable quantities in the Gondwana rocks at Dubar, Amdari, Barondi near Piparia and at many places between Chandia and the Mahanadi river. The fire clay of Chandia alone has been exploited.

Sir Cyril Fox[1] has mentioned the bleached shales occurring associated with the carboniferous shale or slate at the copper mines near Beria and Goriara, 3 miles south of Sidhi. They do not possess the requisite plasticity for normal pottery clay, but may prove as a satisfactory fire clay.

Fire clay occurs at Umaria and exposures of such material extend as far as Chandia and pits 5 to 6 feet in depth have been sunk. In the neighbourhood of Chandia both fire clay and pottery clay appear to occur. The former is generally grey and cream-coloured, while

1. *The Mineral Resources of Rewa State*, 1945, p. 33.

the latter is lighter in colour. The clay from Bania appears suitable for the manufacture of fire-bricks, saggars and even white tiles. Oriental Pottery Ltd., Chandia are engaged in the manufacture of white tiles and fire-bricks.

Raniganj Coalfield

Large deposits of fire clay of very good quality occur in the Barakar series of the Raniganj coalfield. According to E. R. Gee the chief localities comprise the Garphalbari-Dahibari grits and coal measures to the north and south of the Kudia *nala*, to the south-east of Damagaria, the lower measures of Radhaballavpur-Shyamdi-Pahargora area, the Garh-Dhemo-Churulia area and the lower Barakar outcrops of the Trans-Adjai area. The thickness of the seams of clay varies from 1 to 6 feet. The fire-bricks manufactured from these clays have given ample satisfaction in the iron and steel industry of India. These clays are used by the following concerns :–

(1) Kumardhubi Fire-brick and Silica works, Ltd. (Agents : Bird and Co. Ltd.)

(2) The Reliance Fire–brick and Pottery Co., Ltd. (Agents : Andrew Yule and Co., Ltd.)

(3) Gulfabari Fire–brick works, Ltd. (Agents : Burn and Co. Ltd.)

Bihar

Fire clay occurs at several localities on the western side of the Rajmahal hills, Santhal Parganas, Bihar. It occurs associated with the Damuda sandstones which

are exposed along the western margin of the hills, especially in the Hura, Dhamni and Chuperbhita coalfields. The thickness of the beds varies from 1 to 15 feet, but they are generally about three feet in thickness and many of the clays are infusible and their texture compares very favourably with the finest Stourbridge clay. It is suitable for the manufacture of refractory articles including fire-bricks. For a detailed list of these localities the interested reader is referred to Murray-Stuart's[1] communication on the subject. The clay obtained from Mangal Hat, which marks the most convenient locality, is used after washing by the Calcutta Pottery Company.

White fire clay is also found interstratified with Damuda sandstones near Piaram in the Hura coalfield and the beds are four to five feet in thickness.

Fire clay also occurs at Rajhara in the Daltonganj coalfield in the Palamau district.

Assam

Fire clay occurs at Jowai in the Khasi and Jaintia hills of Assam. This clay is reported to be as good as fire clay of Raniganj. It is not served, however, by good communications, but has the advantage of the occurrence of coal in the neighbourhood.

White clay occurs in many places at the junction of the Cretaceous sandstones and the underlying gneiss. A sample from one of these localities was examined at the Imperial Institute, London and it was found to be suitable for the manufacture of fire-bricks.

1. *Rec. Geol. Surv. Ind.*, vol. XXXVIII, 1910, pp. 138-142.

Madras

Refractory clays occur in abundance near Rajahmundry. Their plasticity is good and they were not fused at 1200°C and maintained their white colour at that temperature. The clays could be used for the manufacture of fire-bricks. The deposits are served by good communications and coal is available from the Singareni collieries, about 150 miles away.

Hyderabad-Deccan

Fire clay occurs at Konasamudram in the Nizamabad district. This clay is highly refractory and was used by the old iron smelters in making their furnaces and crucibles for steel manufacture.

A good quality fire clay occurs in the Upper Gondwanas about a mile south of Pachgaon which is 4 miles north-east of Asifabad railway station. The deposit has a thickness up to 6 feet and extends over an area of about a square mile. It is smooth, free from grit and is pale gray to pale pink in colour. It is used in the manufacture of bricks, pipes, tiles, etc.

West Punjab

Fire clay occurs at Ratucha near Khewra in the eastern Salt Range. It lies below the Eocene coal and the bed is 5½ feet in thickness. Professor Mellor has given a favourable report on this clay and the deposit is being worked by Lahore Industrials Ltd.

CHAPTER XIII

Mineral Resources (contd.)

Steatite

Steatite, popularly called soapstone or potstone, is a variety of talc. It has a characteristic soapy feel, is generally foliated and has a micaceous cleavage.

Central Provinces

Large deposits of steatite occur on both sides of the Narbada river in the neighbourhood of Bhera Ghat in the Jubbulpore district of the Central Provinces. The author has studied these deposits in detail and a brief account was published in the *Proceedings* of the 32nd. Indian Science Congress. The most important locality is Bhera Ghat and Messrs Burn and Co. Ltd. hold a mining lease here. The mineral occurs in compact foliated masses and the colour is variable: white, greenish, yellowish, etc. The steatite mined from this locality is sorted into three grades. The first grade comprises white and greenish steatite, some of which in thin splinters may appear translucent. The second grade comprises yellow steatite or yellowish mixed with white. The third grade comprises impure and weathered material. At the time of the author's a visit in 1943 a few pits were being worked and one of them had a depth of 26 feet 5 inches and measured 9 feet in width. Some of the abandoned quarries, however, may be as much as 300 feet in depth, with a face of more than 50 feet. Both male and female labour is employed in the quarries. Some of the pieces extracted measure more than

two feet in size. With depth a pit or a quarry is filled with water and pumping arrangements have to be made. The steatite is exported to a number of places, viz., Bombay, Calcutta, Cawnpore and to a smaller extent to Jalgaon, Akola, Khandwa, etc. Steatite from this area was once mined on a large scale, but the industry declined on account of competition with steatite from Rajputana. The railway freight on Rajputana steatite, the author was informed, works much cheaper. With regard to the origin of this steatite, it may be noted that the marble rocks consist of dolomite and wherever this rock has been invaded by basic dykes, soapstone has developed at the contact sometimes along with tremolite. In places the wall rock is a dark green soft and smooth talcose schist.

Steatite also occurs across the Narbada at Gowari, Lalpur and Darwara. Bombay Mining and Prospecting Syndicate hold a mining lease here. The mineral quarried at Bhera Ghat is exported from Bhera Ghat Railway Station, while the steatite mined across the river presents difficulty by way of transport.

Large quantities of steatite occur in a hill near Rupaund, only a few miles from the Katni-Bilaspur line.

Rajputana

Steatite is known to occur at three localities in the Jaipur State. The steatite quarry of Gisgarh lies immediately west of the town. The greatest thickness of the steatite band is two feet. It is dark green in colour.

Rich pockets of steatite deposit of Morra–Bhandari extend for about 5 miles between Dhota and Morra and

one of the beds is 25 feet in thickness. The workings have been put down in the richer pockets of talcose schist having white or pale green colour and the steatite is of good quality.

The steatite of Dogetha, $2\frac{1}{2}$ miles north–east of Raialo occurs in the Raialo limestone. It had been excavated in a width of 30 yards, but the deposit is much wider. It had been quarried in an open cutting for about 50-60 yards along the length of the deposit. The steatite is milky-white or very slightly greenish in colour and is very pure. This steatite is exported to Amritsar and Cawnpore.

Steatite is also known to occur in Mewar. Several grades are known to occur in the dolomitic limestone at Jeoria, Mewar, the best being pearly-white in appearance. According to B. B. Gupta deposits of variable grade occur near Rikhabdeo and Khandmin in Udaipur State.

Bihar

Steatite occurs in Bihar. Talcose schists occur in Kolhan near the sheared margins of peridotite rocks which are intrusive into the slates of Dharwar age. Talc schists are also intercalated with the Dharwar schists in the Dhalbhum district. Several deposits of soapstone are exploited by the local villagers at Bhelaipahari and two miles east of Kokara in Dhalbhum. Similar deposits occur near Maheshpur, Burudih, north-west of Khejurdari and north of Digha. According to J. A. Dunn talc is found associated with the Dalma volcanic rocks in several places. In Seraikela State steatite has been extracted west of Bara-Kadel.

Madras

In Madras, there is a small production from Salem and Nellore districts. An important deposit of compact steatite has been largely worked at Tundagundapalaiyam in the Salem district. In the Nellore district it occurs near Jogipalli where talc schists are found on the right bank of the Penner between Kaluvaya and Thalagapur. It also occurs at Musila Cheruvu and Maddavaram in the Kurnool district.

Idar State

According to C. S. Middlemiss a large deposit of steatite, which extends for over a mile and has a width exceeding 200 feet, occurs near Dev Mori, Idar State, Bombay. The reserves of the mineral have been estimated to be 2 million tons within the first 20 feet from the surface.

Production :- The main producing centres are Jubbulpore, Guntur in Madras, Jaipur State and Hazaribagh in Bihar. In 1938 there was total production of 18,500 tons valued at Rs. 1,68,580. Guntur district and Jaipur State produced more than 7,000 tons each. The production in 1944 was 21,392 tons which fetched Rs. 4,61,489.

Uses :- Steatite on account of its soapy feel, softness and being bad conductor of heat and electricity is put to a very great variety of industrial and other uses. On account of its softness it can be easily cut and dressed. It is carved into a number of articles, e. g., various kinds of boxes, powder boxes, ornamental

articles, penstands, models of temples, slate pencils, paper weights, etc. It is also cut into panels for switch boards, laboratory and kitchen sinks, etc. It is also used as a special refractory, resistant to corrosion and is thus employed as lining for furnaces and stoves. But the mineral is very largely used as a filler in the textile, paper, rubber, paint and soap industries. It is also used as a polishing agent for leather and foodgrains, especially rice and *arhar* dal. Being soft with a greasy feel it is also used as a lubricant. The best white grade forms the french chalk, the basis of many toilet and cosmetic manufactures.

Monazite

It is an anhydrous phosphate of the rare earth metals, viz., cerium, lanthanum, neodymium, etc. Its colour is light yellow, red or brown. Its value is due to the small amounts of thoria it contains. Grains of monazite occur in many granites and gneisses. Deposits of commercial value occur in (a) beach sands and (b) stream gravels which are derived from the disintegration of monazite-bearing rocks.

Monazite sands occur for about a hundred miles between Cape Comorin and Quilon on the Travancore coast. The mineral occurs in the pegmatite intrusions, but is perhaps chiefly derived by the disintegration of gneisses forming the Travancore hills. In places, as a result of wave action large quantities of monazite have been concentrated. The mineral is recovered by washing and magnetic separation. Its thoria-content varies from 8–10 per cent. It is noteworthy that India

possesses the greatest reserves of monazite known in the world and its quality with regard to its thoria-content is also superior.

Other Localities:–(1) This mineral is also known to occur in the sands occurring in the Tinnevelly district to the east of Cape Comorin. (2) It also occurs near Waltair in the Vizagapatam District. (3) A variety, which contains 2¼ per cent. of thorium, has been recorded from the pegmatites of the Bangalore District in the State of Mysore. (4) It also occurs as beautiful crystals associated with other rare minerals like pitchblende and columbite in the pegmatites of the Gaya district, Bihar.

A black mineral, which had been provisionally identified as thorianite, has been found at Thadagay Hill in Travancore. The specific gravity is 10.03 and its partial analysis yielded 32.3 per cent. of thoria and 39.9 per cent. of uranium oxide.

The demand for monazite for its thoria-content, used in the manufacture of incandescent gas mantles, has declined on account of the use of electricity. The exploitation of monazite started in 1911 and in 1918 the output was 2,118 tons valued at Rs. 8,82,285, but in 1925 the production is recorded to be only one cwt. But subsequently there has been a revival in the demand for ilmenite which also occurs associated with monazite. In 1938 the output of monazite rose to 5,221 tons.

Monazite is exported to New York, Paris and Hamburg.

Uses:– It has already been stated that monazite is valued for its thoria-content which is converted into thorium nitrate used in the manufacture of incandescent gas mantles. With the greater use of electricity, the demand for these mantles has fallen. However, the use of thorium in radio tubes and of cerium in the manufacture of pyrophoric alloys have sustained a market for this mineral.

Recently, it has been found that uranium and thorium are two chief radioactive elements which undergo atomic disintegration. During this disintegration both heat and atomic energy are evolved. During the Second World War this energy was used in making devastating atom bombs which caused terrific havoc in Hiroshima and Nagasaki in Japan. This energy can also be used for various industrial purposes in peace time. According to D. N. Wadia[1] the reserves of monazite in Travancore have been estimated to be 2,500,000 tons. The quantity of available thorium from these beach sands is about 150,000 tons. It may be noted that the entire production from India was exported, but now that this mineral is a possible source of atomic energy, steps are being taken by Government to conserve this valuable mineral and exports have been stopped.

Asbestos

Asbestos comprises a number of minerals which possess a well-marked fibrous form. The true asbestos,

1. Mineral Research and Planning of Mineral Industry, *Trans. National Inst. Sci. Ind.*, vol. II, 1947, pp. 225-226.

which can be spun easily, is the chrysotile asbestos, while the inferior varieties are represented by amphibole asbestos. In the latter case the fibres can be felted together for various purposes.

Madras

The most important deposit of asbestos, which is of excellent quality, is near Brahmanapalle in the Cuddapah district, Madras. Here thin veins of chrysotile asbestos are seen running in dolomitic limestone. They are also observed at the contact of limestone with the intrusive dolerite. According to A. L. Coulson, the Brahmanapalle-Lopatanutula occurrences extend over a distance of 9½ miles and the asbestos zone is rarely more than three inches in width. Similar, but smaller deposits occur at Rajupalem in the Kamalapuram taluk of the Cuddapah district and near Malkapuram and Joharapuram in the Kurnool district. The production from the Cuddapah district was about 30 tons *per annum* for the years 1939-1941 with an average value of Rs. 900 per ton.

Mysore

Amphibole asbestos is found at several localities in Mysore State. At Kabbur in the Hassan district the mineral occurs in long fibrous sticks, several feet in length, but it is brittle and suffers from the lack of tenacity. It also occurs in the Bangalore district.

Rajputana

Chrysotile asbestos occurs at Kaolai in Ajmer-Merwara close to the boundary of the Jodhpur State. It occurs

in fine veins, the largest being about a quarter of an inch in width, which are seen running through a band of serpentine which occurs in Ajabgarh limestone.

A deposit of chrysotile asbestos occurs a little W. S. W. of the Gudas village in Ajmer-Merwara. The author visited this locality in 1947 and a brief account was published in *Journ. Sci. and Ind. Res.*, vol. VII, 1948. There is a hill of altered peridotites which in fact is the northernmost of the three serpentinised peridotite hills. On its eastern slopes there is a quartz vein and a small mica pegmatite injected in the biotite schists which become gernetiferous at the contact.

A pit for asbestos, about 50 feet in depth has been sunk in the northernmost hill of the altered peridotites. It occurs in patches as well as in veins which are both vertical and inclined. They vary from a few inches to about two feet in thickness. Sometimes the two veins are hardly a few inches apart. The mineral continued to the bottom of the pit and its base had not exposed. As compared to the previous occurrence of Kaolai this locality appears far more promising.

This locality is easily accessible both by road and railway. In a direct line it is about 9 miles from Ajmer railway station and can be approached from Ajmer-Kishengarh road by a cart track, which is open to motor traffic.

Asbestos also occurs at Sendra in Ajmer-Merwara and also at Delawas and Guda in Alwar.

Seraikela State

Amphibole asbestos occurs at several places in this

State, but the Bara Bana deposit is only of commercial importance. Asbestos occurs in 'logs' often having a length of 14 feet and a diameter of 12 inches, but for spinning purposes it has been found to be weak and brittle. It could, however, be used for insulating, acid-resisting, and other purposes.

Uses:—This mineral is put to a variety of uses owing to its properties and thus it has been found as indispensable in modern industry. It is used as an important fire-resisting material. The fibre can be spun and made into ropes, felts and cloths. In admixture with cement it is used in the manufacture of building sheets, ceilings, floorings, fire-proof covering for wood-work, roofing tiles, etc.

India imports annually large quantities of asbestos goods valued at many hundred thousand of rupees. Many of these materials are manufactured from inferior grades and it is quite possible that with suitable machinery at least some of the articles could be manufactured in India.

Gypsum

A brief account of the gypsum deposits of India was given in Part I of this work, pp. 249-251. A somewhat more detailed account is given in the sequel.

West Punjab

Commencing from the north, enormous quantities of the mineral, both in the form of massive variety and as selenite crystals occur associated with the salt deposits of the Salt Range in the districts of Jhelum, Shahpur and Mianwali. These deposits extend from the

neighbourhood of Jalalpur in the east to as far as Kalabagh on the Indus. The rocks, with which gypsum is associated, are known as the Saline series. It sometimes forms beds, having a thickness of 50 feet or even more. It is quarried at Khewra and other places. It also occurs near Dandot, as also in the Makrach, Warchha and Jansukh gorges. Large deposits occur near Daud Khel and according to E. R. Gee, any of the main deposits may contain a few million tons. This mineral also occurs in large quantities in the Attock and Rawalpindi districts where it is found associated with the Lower Chharat stage in beds having a thickness of 2 to 3 feet.

N. W. F. P.

Large quantities of this mineral occur in the Trans-Indus Salt region in the Kohat district of the Frontier province. The mineral occurs in the hills near the Indus, and extends as far as the neighbourhood of Bahadur Khel over a distance of 50 miles. The mineral is associated with the upper portion of the Eocene Nummulitic rocks, and masses, measuring up to 200 feet in thickness, occur with intercalations of clay and shale. According to E. R. Gee the resources of this mineral here are unlimited. Large reserves of this mineral also occur in the Shirani country.

Sind and Baluchistan

The Jurassic, Cretaceous and the Tertiary shales in these areas contain large quantities of this mineral. In Baluchistan beds of gypsum, five to ten feet in thickness, are known to occur associated with the Eocene shales in the Bugti and other hills.

Kashmir

Large deposits of this mineral also occur in Kashmir. They have been formed by the alteration of pyritous limestone, and extend for 25 miles near Braripara in the district of Uri.

Kangra :– Gypsum, snow-white in colour, and suitable for ornamental purposes or for the manufacture of plaster of Paris, forms large deposits in the Lower Spiti Valley. The largest deposit, as observed by Mallet, occurs on the left bank of the Spiti river opposite Shalkar. Other deposits are found near the Chango Pass and in the main valley between Shalkar and Huling.

According to Hayden large deposits of gypsum occur between the Lipak and Yalung river to the south of Shalkar.

United Provinces

Large deposits of gypsum occur in the United Provinces. Several deposits of this mineral occur in the neighbourhood of Sahasradhara near Dehra Dun. They occur (i) near Sahasradhara, (ii) near Manjhara, (iii) Silkote, etc. These deposits are generally associated with limestone and dolomite. The gypsum has been formed by replacement of these rocks by the action of the sulphuretted waters and such springs are found in this vicinity even today.

Likewise, deposits of gypsum occur in the Garhwal district and in the Tehri State near Rishi Kesh. Gypsum is also known to occur on the Nihal *nadi* between Kaladhungi and Naini Tal in the Kumaun Hima-

layas. It may be noted that the deposits near Sahasradhara and Rishi Kesh are not difficult of access and are already being worked to some extent.

Rajputana

Extensive deposits of gypsum occur in Rajputana. In Jodhpur State deposits of this mineral occur near Kurlo, Madpura near Kavas railway station and Shaokar between Barmer and the Luni river. An important deposit occurs at Bhadwasi railway station, 8 miles N.N.W. of Nagaur, where a bed of this mineral, five feet in thickness, extends over an area of 8 square miles. Other localities, where this mineral forms important deposits, are Barmer and Pilanwasi. The latter deposit is fairly extensive and the mineral is also of better quality.

Madras

Gypsum occurs abundantly in the form of fibrous plates and concretions in the Cretaceous rocks in many parts of the Trichinopoly district. It is reported to be most abundant in the Utatur group, especially in the clays to the east of Utatur and N. E. of Marattur.

Uses :- Gypsum finds a number of uses. It is extensively used in the manufacture of cement and plaster of Paris, also in paints and rubber manufacture. It is used as surface dressing for agricultural lands, and as a fertilizer with considerable benefit to crops. It can be used in the reclamation of *usar* lands. It is also used in the manufacture of sulphuric acid.

Barytes

Madras :- The biggest deposits of barytes occur in

Madras Presidency. The deposit of Betamcherla in the Kurnool district was worked as early as 1918. In 1932 A.L. Coulson investigated the barytes deposits of the Cuddapah, Anantpur and Kurnool districts. He found 60 localities, 13 of which were in the Cuddapah district, 11 in the Anantpur district and the remaining 36 in the Kurnool district. The mineral occurs either as replacement or fissure veins in the Vaimpalli limestone of the Cuddapah System or in the associated dolerite and basalt sills. At Kottapalle in the Pulivendla *taluk* of the Cuddapah district the reserves of barytes in the first 20 feet of depth have been estimated at 30,000 tons, while those of the Matssukota deposit in the Anantpur district are 75,000 tons. Four veins occur near Nerijamupalle in the Anantpur district; the largest has been traced for more than half a mile in length and with a width varying from 3 to 11 feet.

Important deposits of barytes occur in the Dhone *taluk* of the Kurnool district at Balapalapalle, west of Betamcherla, Hussainpuram, Rampuram, Valasala, Rahimanpuram, and Gattimanikhonda. It is also found at Janapalacheruvu in the Cumbum *taluk* of the same district.

Rajputana :– Barytes also occurs in the Alwar State, Rajputana. According to S.K. Roy there are four deposits : (i) at Bankhera, 3 miles south-west of Alwar city, (ii) at Ramsinghpur, 10 miles south-west of Rajgarh railway station, (iii) at Jamroli, 7 miles south-east of Rajgarh railway station and (iv) at Sainpuri, 4 miles N.N.E. of Parisal railway station. The last locality is

the most important where a vein of pure white barytes with a thickness of about 15 feet has been traced for 110 feet.

It is also known to occur in Bharatpur State.

Bihar :– Barytes is found at Chas Road in the Manbhum district and Kolpotka in the Singhbhum district

It also occurs at Khatangtola in Gangpur State.

Production :– In 1937 the production of barytes in India was 15,689 tons which decreased to 8,075 tons in 1938, but in 1940 it had risen to 18,778 tons. It was 22,500 tons in 1941.

Uses :– Barytes is used chiefly in the paint industry and as a filler for paper, rubber, oil-cloth, etc. It is used in heavy liquids for oil-drilling. It is also used as a furnace lining and in the manufacture of barium chemicals. It is the source of metallic barium.

Beryl

Beryl, the silicate of aluminium and beryllium, is the commercial ore for beryllium, a metal used in making useful alloys with copper, aluminium, magnesium, nickel, iron, etc. When alloyed with copper it acts as a hardener and imparts strength to copper.

Beryl generally occurs in pegmatites associated with granites and is found in Rajputana, Bihar and Madras.

Rajputana

Ajmer-Merwara :– The most important localities, where this mineral is found in Rajputana, are those of Ajmer-Merwara and Mewar (Udaipur State), a descrip-

tion of which has been given by K. L. Bhola.[1] The pegmatites are genetically connected with the Erinpura Granite of post-Delhi age. Beryl is often recovered as a by-product in mining for mica, felspar or pink quartz.

A coarse pegmatite, over 1,000 feet in length and 75 to 100 feet in width, occurs at Bisundni near Deoli Cantonment. It contains numerous large crystals of beryl, some of them being 20 feet in length and four feet across. A single crystal is reported to have produced 15 tons of beryl. In 1933 and 1934 this deposit yielded 1,000 tons of beryl. Some transparent pale green beryl of gem quality is also associated. It may be noted that beryl has been found in sufficient quantity here to make mining payable for it alone. The ore exported from Bisundni was delivered at £ 10 per ton c.i.f. Hamburg. According to Dr. A. M. Heron[2] the cost of production in Ajmer-Merwara ranges from Rs. 35 to Rs. 60 per ton at the railhead.

A lenticular pegmatite, 130 feet in length and 40 feet in the thickest part occurs at Tehari. Crystals of beryl, 5 feet in length and a foot in diameter, occur and the deposit has produced many tons of beryl.

At Kharwa a beryl-bearing pegmatite occurs. Six tons of beryl had been produced as a by-product in course of felspar mining.

Beryl is also known to occur two miles west of Sarwar, on either side of the Nasirabad-Deoli road.

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1. A short note on the beryl deposits of Ajmer-Merwara, *Trans. Min. Geol. Inst. Ind.*, vol. XXIX, 1934, pp. 127-139.

2. *Trans. Min. Geol. Inst. Ind.*, vol. XXIX, 1935, p. 301.

Narnaul :– The author has described an unusual occurrence of beryl near Narnaul in Patiala State in the *Journ. Sci. and Ind. Res.*, vol. 3, 1945, p. 423. Crystals of beryl occur in the coarsely crystallised calcite, a little over two miles north-west of the northern end of the town of Narnaul. This occurrence is almost unique in India, perhaps one of the rare instances of its kind in the world as beryl generally occurs in granites and pegmatites.

Mewar :– Large crystals of beryl, up to 18 inches across, occur in a pegmatite extending over an area of 600 feet by 500 feet near Deora.

Near Jamoli a pegmatite measuring 500 feet by 280 feet builds a hill and on its northern and eastern slopes beryl crystals were found to be scattered some of which had a thickness of $2\frac{1}{4}$ feet. There are other pegmatites occurring in this State which contain beryl.

All the beryl exported from India has been derived largely from Rajputana.

Bihar

Beryl is also found as an accessory associated with the mica-bearing pegmatites of Gaya and Hazaribagh. It is fairly common in the mica pegmatites of Kodarma forest, Jorasemar and Gawan in Hazaribagh.

Madras

The mica pegmatites of the Nellore district also contain beryl. The mineral is known to occur at several localities near Gudur and small quantities of beryl are produced during mining for mica.

Crystals measuring three feet have been found. However, no attempt has yet been made to separate and market the mineral.

Pegmatites associated with granites occur in several parts of India, e.g., the Central Provinces, Madras, Hyderabad-Deccan, Orissa, Assam, etc., which are likely to contain beryl and have not been properly investigated as yet.

Titanium

It has been noted already that ilmenite, an important ore of titanium occurs associated with the black sands occurring on the beach of Travancore. Other associated minerals are zircon, which is also a valuable refractory, garnet and quartz. Rutile, which is composed of titania, occurs in appreciable quantities associated with these sands and is won from the zircon fraction by electromagnetic separation. These sands, as stated already, extend for a distance of 100 miles from Nindakara near Quilon on the West Coast to Cape Comorin and beyond on the east coast as far as Lipuram. These beach sands are being worked by the Travancore Minerals Company, Ltd. and their works are located at Manavalakurichi. They are 8 feet in thickness and contain about 50 to 70 per cent. of ilmenite. This mineral also occurs a little further inland as a bed, about 8 feet below the surface. This deposit is being worked by Messrs Hopkin and Williams, Ltd. From Nindakara to Kayankulam, north of Quilon occurs another stretch of productive sands. The Travancore Minerals Company, Ltd. operate the

beach sands at Kovilthatam, 8 miles north of Quilon, while Messrs F. X. Pereira and Sons exploit a bed a little farther north. Smaller deposits of beach sand occur at other places on the Coast of India, e. g., on the Tanjore Coast.

It may be noted that some of the laterite and bauxite deposits of India contain a good percentage of titania which is recovered as a by-product in the manufacture of alumina. With the development of aluminium industry in India it is quite likely that titania will be an important by-product.

Large deposits of titaniferous magnetite have been found in Singhbhum in Bihar and Mayurbhanj. These contain varying amounts of titania, with a maximum of 28 per cent. Many occurrences of titaniferous magnetite are known from Mysore State, especially in the Channapatna *taluk* and is also found associated with the basic and ultra basic rocks of the Nuggihalli schist. Titaniferous magnetite is also a common constituent of the Deccan Trap. It gets concentrated in laterites and bauxites and also in the detrital black sands derived from them. The proper utilisation of these ores offers a useful field for investigation. They may prove to be source of titanium along with vanadium.

Titania is used in the manufacture of titanium white which is a valuable pigment used alone or in conjunction with other paint materials like barytes, gypsum, zinc oxide, etc. It possesses great opacity and is non-poisonous as compared to white lead. It is practically inert and is highly resistant to the weather and corrosion. It is also used in making varnishes, high class

enamels and lacquers. Titanium finds use in the production of a great variety of alloys, both with ferrous and non-ferrous metals. It is also used as a filler in electrodes and in making smoke screens. Titania is an excellent mordant in some cases.

In 1938, the production of ilmenite was 252,220 tons valued at a little over Rs. 15,00,000 which calculates to about 10 shillings per ton, while the price of the manufactured oxide is £ 100 and more per ton. Since 1927 India has been the largest producer of ilmenite in the world. Up to 1942 the Travancore beach sands had produced and shipped over one million tons of ilmenite. The production and exports of ilmenite for the years 1938, 1939 and 1940 are shown below :-

Year	Production in tons	Export in tons
1938	252,220	225,592
1939	237,835	236,476
1940	263,152	290,490

D. N. Wadia[1] has aptly noted: "there is no other industrial mineral in which negligent and wasteful trade practice has caused so much harm as in the uncontrolled export of ilmenite for a ridiculously low return. A valuable national asset is being dissipated by unrestricted export of this mineral in the raw state. This is a glaring case that demands an embargo on further export."

1. Mineral Research and Planning Industry, *Trans. National Inst. Sci. Ind.*, vol. II, 1947, p. 225.

CHAPTER XIV

Mineral Resources (Contd.)

China Clay

An account of important deposits of refractory clays fouud in India has been given under 'Fire clay'. It is now proposed to give an account of kaolin or china clay suitable for pottery and other uses. It may be noted, however, that at times it is difficult to draw a line between a fire clay and a pottery clay as sometimes after levigation a fire clay may prove equally useful for pottery making. On the other hand kaolin is the most refractory clay and does not show vitrification below 1,750^0 C. Owing to its high cost, however, only the inferior grades are used for the manufacture of refractories. It is chiefly used as a bleaching clay and also as a pot clay in ceramic industry. In the sequel a concise account of the important deposits of china clay, found in India, is given.

Delhi

Commencing from the north, kaolin occurs at Kasumpur, 5 mil.s south-west of New Delhi and the material is used by the Gwalior Pottery Works near Safdarganj, 3 miles south-west of the deposit. Two other occurrences are over a mile to the south, near the village of Maihpalpur. The kaolin has been derived from altered pegmatite intrusive into Alwar quartzites and the mineral occurs in the form of beds and pockets of varying size and naturally the portions low in iron content are worked. There is an overburden of 12 feet

over the pegmatite and the quality of the clay improves with depth. The purest clay is fairly white in colour. The clay is refined by levigation and sifting. The articles manufactured are fire-bricks, glazed tiles, crockery, sewer pipes, acid jars, electric insulators, etc.

Bihar

Rajmahal Hills :—Valuable deposits of china clay occur in the Rajmahal hills, Santhal Parganas. There are three modes of occurrence of this china clay.

First it occurs as a decomposition product of felspar in the gneisses and schists. The deposits of Katangi, Karanpur and Dodhani in the Santhal Parganas and Patarghatta in the Bhagalpur district represent important examples belonging to this group. The china clay of the first three localities is quite white, free from quartz and other mechanical impurities. In physical properties it has been stated by Murray Stuart[1] to resemble Cornish china clay. They are quite refractory and should prove suitable for the manufacture of white porcelain and china-ware. The thickness of the Patarghatta deposit varies from 40 to 100 feet. A pottery works managed by Mr. G. Macdonald flourished at Patarghatta in 1860.

Secondly it occurs associated with white Damuda sandstones where it has been formed by the decomposition of felspar present in the sandstone. The important deposit of Mangal Hat in the Santhal Parganas furnishes a notable deposit of this group. Here china clay is obtained from the sandstone by crushing, washing

1. *Rec. Geol. Surv. Ind.*, vol., XXXVIII, 1910, pp. 134.

and settling and is used by Calcutta Pottery Company for the manufacture of china and porcelain.

Thirdly beds of white china clay occur interbedded with the white Damuda sandstone. Such deposits occur at Patarghatta and also in the Hura Coalfield.

Chota Nagpur :—Deposits of kaolin occur associated with the granite-gneiss forming numerous detached plateaux in the Ranchi and Palamau districts of Bihar. These plateaux, as noted already, are great repositories of bauxite and laterite, but with some of them large deposits of kaolin are also associated. The author has investigated kaolin deposits of Bagru, Jogi, Lalmattia, Dudha Pats, etc. and a detailed account of the kaolin deposit of the Bagru plateau has appeared in the *Trans. Cer. Soc. Ind.*, vol. I, 1942, pp. 94-107. This deposit of kaolin is situated about 1½ miles W. N. W. of the village of Bagru which is about half a mile below the base of the plateau. It is exposed at an elevation of 3,300 feet above sea level, close to where the south-eastern spur of the Bagru plateau commences its descent. The deposit is under six miles W. N. W. of the small town of Lohardaga which is 46 miles from the town of Ranchi, which is another 30 miles from Ranchi Road Railway Station on the East Indian Railway. The plateau of Bagru is the higher plateau with a maximum altitude of 3,648 feet above sea level. In fact the plateau of Bagru is one of this higher series. The kaolin has been derived from porphyritic hornblende-granite-gneiss.

The kaolin is milky-white, dull white or cream-coloured with a very faint pinkish tinge in the upper

portion, sometimes with bands of yellow, brownish and red. The clay is distinctly unctuous, plastic and fine-grained. The coarse material associated with the clay consists largely of quartz with some felspar, partially kaolinised and was separated by the usual process of washing. The tests on shrinkage, porosity, tensile strength and suspensibility were carried out and the interested reader is referred to the communication cited above. The clay appears suitable for the manufacture of sanitary ware, cheap crockery and decoration articles. It is undoubtedly a primary clay of residual origin and has been formed by the hydrothermal alteration of the gneiss. It may be noted that other materials like felspar, quartz, graphic granite, which find use in ceramic industry, occur in the same neighbourhood.

Singhbhum District :— Deposits of kaolin occur in granitic region, particularly along the margin of the granite. Important deposits occur at Hat Gamaria, Raghunathpur, Pandrasali, Majri, Madkamhatu, Metrabandi, Kharhi Dongri, Dharadih, etc. After levigation they form good bleaching clays. Many concerns work these deposits, perhaps the largest being the Maharaja of Kasimbazar China Clay Mines at Hat Gamaria, some 30 miles south of Chaibasa in the Singhbhum district. A quarry measured 600 feet in length, 400 feet in width and 70 feet in depth in 1930. Owing to the percolation of water it has not been found possible to go deeper.

These clays find use as pot clays and also as fillers in the paper industry. Small quantities of the superior

grades are exported to Bombay for use in the textile industry.

Likewise deposits of kaolin are found at Kashmandu, Katehpara, Mahuldiha, Telaipi, Kerangia, etc. in the Kolhan Estate.

Seraikela State

Similar clays are found in Seraikela State, the important localities being Bharatpur, Chapra, Gengeruri, Jaspar, Koludih, Mundakati, Rangmatia, etc.

Orissa

Beds of white clay occur at Kukker (Kekari) and at Naraj on the banks of the Mahanadi and also at Khurda to the south of the above river. The clay, which occurs in rocks of Rajmahal age, is considered to be suitable for ceramic purposes. It had been employed for dressing leather and white washing. Coal occurs in the Talchir coalfield about 60 miles away and the transport facilities are good.

Good kaolin is also known to occur at Jagannath Prasad in the Puri Forest Division.

Gangpur State

A small deposit of kaolin occurs to the north of Manjhapara in Gangpur State. The country is composed of schists, phyllites and quartzites of Dharwar age into which granite and pegmatites are intrusive. The kaolin, which represents a white residual clay, has been derived by the alteration of a pegmatite boss and the hill is known as Mehnda *dongri*. The clay does not fuse up to a temperature of 1,400^0 C. The crude material

is cream-coloured tinged in places by iron oxide and possesses a poor plasticity.

According to D. P. Chandoke, who investigated this deposit, this clay can be utilised in the manufacture of stoneware, sanitary ware, sewer pipes, tiles, etc. It can also be used in the manufacture of electric porcelain, crucibles, saggers, cupola bricks, etc. It can also be employed as a medium quality filler for cardboard, paper, paints, cloth, scouring soap, etc.

The deposit is only $3\frac{1}{2}$ miles from Dharuadih on Bengal Nagpur Railway, which is 300 miles from Calcutta.

Bombay

Good quality kaolin, derived from the alteration of gneiss, occurs near Karalgi in Khanpur *taluk* of the Belgaum district. The material can be used for the manufacture of china and earthenware and as sizing material for cloth and paper-making.

Kaolin also occurs at Eklara and other places in Idar State and was used as a bleaching clay during the Great War of 1914-18.

A large deposit of kaolin occurs $1\frac{1}{2}$ miles west of Castle Rock in the Kanara district and the clay is known to be very refractory. It is somewhat high in iron to be used as a bleaching clay. The deposit might improve in this respect with depth.

The clay from Goa is stated to be suitable for the manufacture of earthenware or porcelain.

The clay deposit, one mile south of Kumbharmatt

and three miles east of Malvan is large and of good quality. Its chemical analyses reveal 1·5 per cent. of iron oxide, but it is probable that its quality might improve with depth. The kaolin is derived from gneiss and is covered with laterite. It did not fuse at 1400° C and remains white after burning. It is considered to be of good quality.

Madras

A number of kaolin deposits occur in various districts of this Presidency.

A deposit of clay, which is a good refractory and possibly a filler, occurs 1½ miles from Gani in the Nandayal *taluk* of the Kurnool district.

Good kaolin has been extracted from the Victoria China Clay Mine near Prabhagiripathnam in the Nellore district. It has fetched Rs. 20 per ton and is used as a bleaching clay.

Thick beds of very pure kaolin occur near Dodabetta in the Nilgiri district.

Hyderabad-Deccan

An important deposit of kaolin occurs at Chintrala in the Nalgonda district. The reserves are roughly estimated at 250,000 tons. The kaolin is stated to be of good quality suitable for ceramic purposes and compares favourably with high grade foreign kaolin.

Kaolin also occurs at Kamṭhana, about 7 miles southwest of Bidar. The clay is covered by laterite and pits 2½ feet square are sunk through laterite to a depth of about 28 feet and at a distance of 30 feet from each

other. The pits are connected underground by tunnels 3 feet in width with intermediate cross cuts. The kaolin is of good quality, which compares favourably with the best foreign china clay. It finds use as a filler for paper in the Sripur Paper Mills.

Mysore State

Many deposits of kaolin occur in Mysore State, particularly in the districts of Bangalore, Hassan, Kolar, etc. An account of the important deposits is given below.

Bangalore District:—A deposit of white kaolin, several feet in thickness in places, extends from Bangalore to Nandidrug in the Bangalore district. The clay is derived from the underlying hornblende-granite and after washing has proved suitable for the manufacture of crucibles when used in admixture with an equal quantity of powdered quartz.

Kaolin is also known to occur near Golhalli and has been formed by the decomposition of felspathic veins in granite-gneiss. The reserves are believed to be considerable as the City Brick and Tile Works, Bangalore consume about 500 tons of washed clay from this deposit *per annum* for manufacturing fire-bricks. Crude clay yields about 28 per cent. of kaolin which at 1,100° C burns practically white It is considered to be suitable for the manufacture of porcelain and earthenware.

Kaolin, which has been formed by the decomposition of micaceous gneiss and pegmatite veins intrusive into it, occurs 2½ miles from Devangudi railway station. Up

to a depth of 30 feet, 8,000 tons of this clay have been proved. The Kolar Brick-Making Company, Ltd., use it for the manufacture of fire-bricks and crucibles.

Good quality kaolin occurs at the base of the Nandagudi hill and the Mysore State Pottery Works use it in the manufacture of saggers.

Hassan District :— Kaolin is known to occur at several localities near Begadi in the Arsikere *taluk* and has been formed by the decomposition of the felspathic veins in the weathered gneiss. The deposits are generally concealed by laterite, but at Appenhalli some 14,000 tons and at Nandihalli about 5,800 tons are visible. The kaolin is pure white in colour and excellent in quality.

Kolar District :—China clay, derived form granite and pegmatite, occurs in the Karadibande block, 7 miles east by north of Malur railway station and the minimum reserves are estimated at 14,000 tons. It is consumed by the Kolar Brick-Making Company for the manufacture of fire-bricks.

Production :— During 1944 the production of china clay was 89,229 tons valued at Rs. 10,28,227. Of this the Eastern States Agency produced more than 45,000 tons, while Bihar ranked next with an output exceeding 23,000 tons, and the production from Mysore was 9,636 tons.

Uses :—It has been noted above that these clays are used as bleaching clays and also in ceramic industry. Bleaching clays should be pure white in colour, free from grit with a good suspensibility in water. They are

used chiefly as fillers in the textile, paper and rubber industries. They are also used in soap manufacture, medicines and paint mixing.

Ceramic clays have the same sort of properties as bleaching clays. Good plasticity is desirable and should burn white.

Conclusion:— Finally the remarks of F. B. Kerridge[1] may be aptly quoted: "properly refined Indian clay deserves a better reputation than it has hitherto enjoyed, particularly for such purposes as paper filling. The consumption of china clay in India is increasing and there appears to be no reason why indigenous production should not fill the greater part of the country's requirement instead of only approximately 50 per cent. as at present."

Cement

Cement industry in India came into being only during the present century, but has made phenomenal progress owing to its great and varied uses together with a great home demand.

In India, excellent limestone and clay or shale for the manufacture of high class cement are abundant close to the railway in various parts. It is noteworthy that the cement manufactured is of high quality and has satisfied the high standards of excellence required by the British Standard specifications. It was first manufactured in Madras in 1904, but its manufacture on a large scale

1. The Working and Refining of Indian Kaolin with special reference to a Singhbhum Deposit, *Trans. Min. Geol. Inst. Ind.*, vol. XXIV, 1930, pp. 295-320.

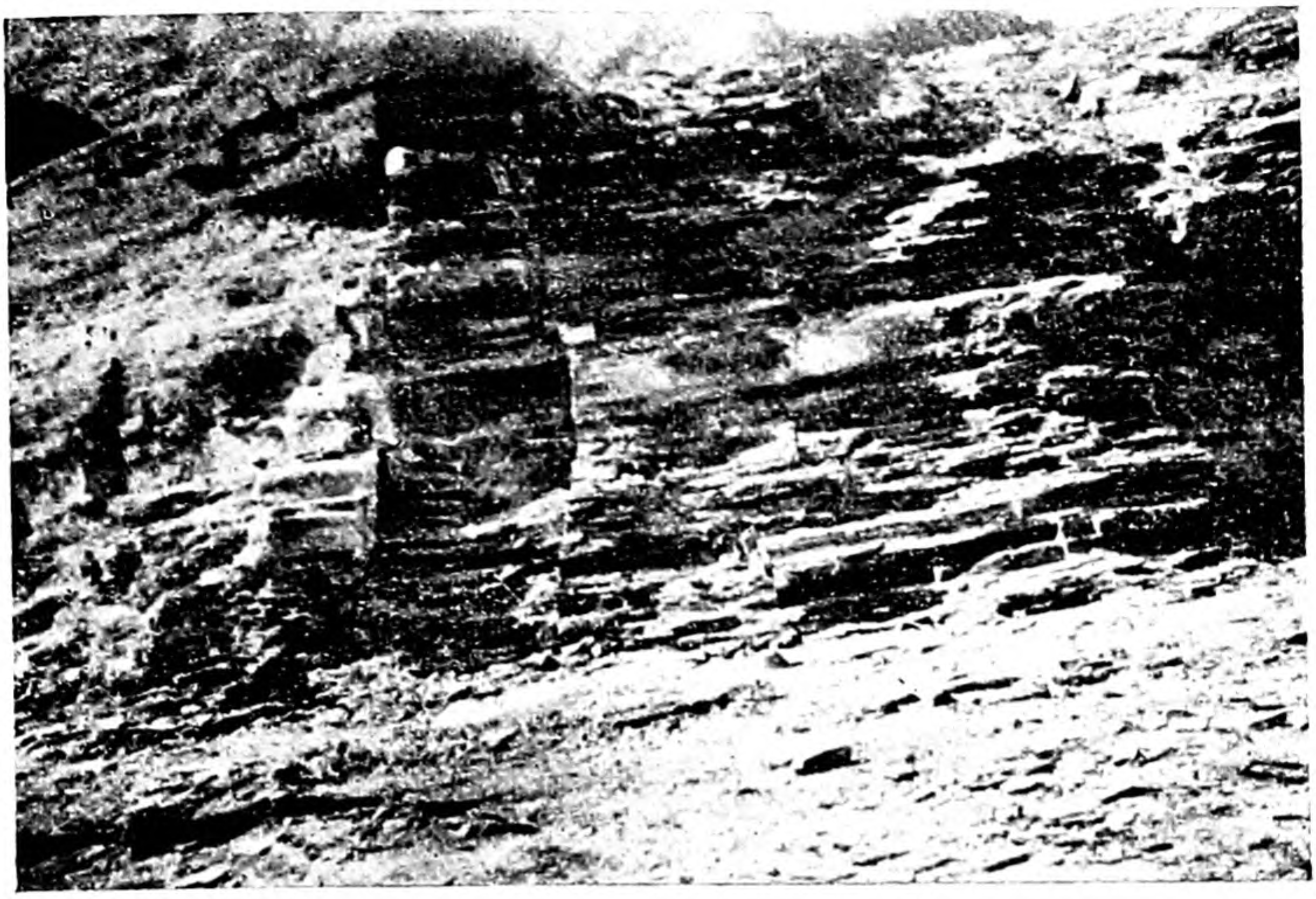


Fig. 1—Limestone Quarry No. 1, Dumerkhar (near Sasaram) of Rohtas Industries, Dalmianagar. This limestone is used in the manufacture of cement. (*Photo: Vishwa Nath Chhibber*)

Fig. 2—Showing the quarried limestone at Dumerkhar ready for sorting and transport. The limestone hills are seen in the background (*Photo: Vishwa Nath Chhibber*).

2

Borrower's No.	Issue Date	Borrower's No.	Issue Date

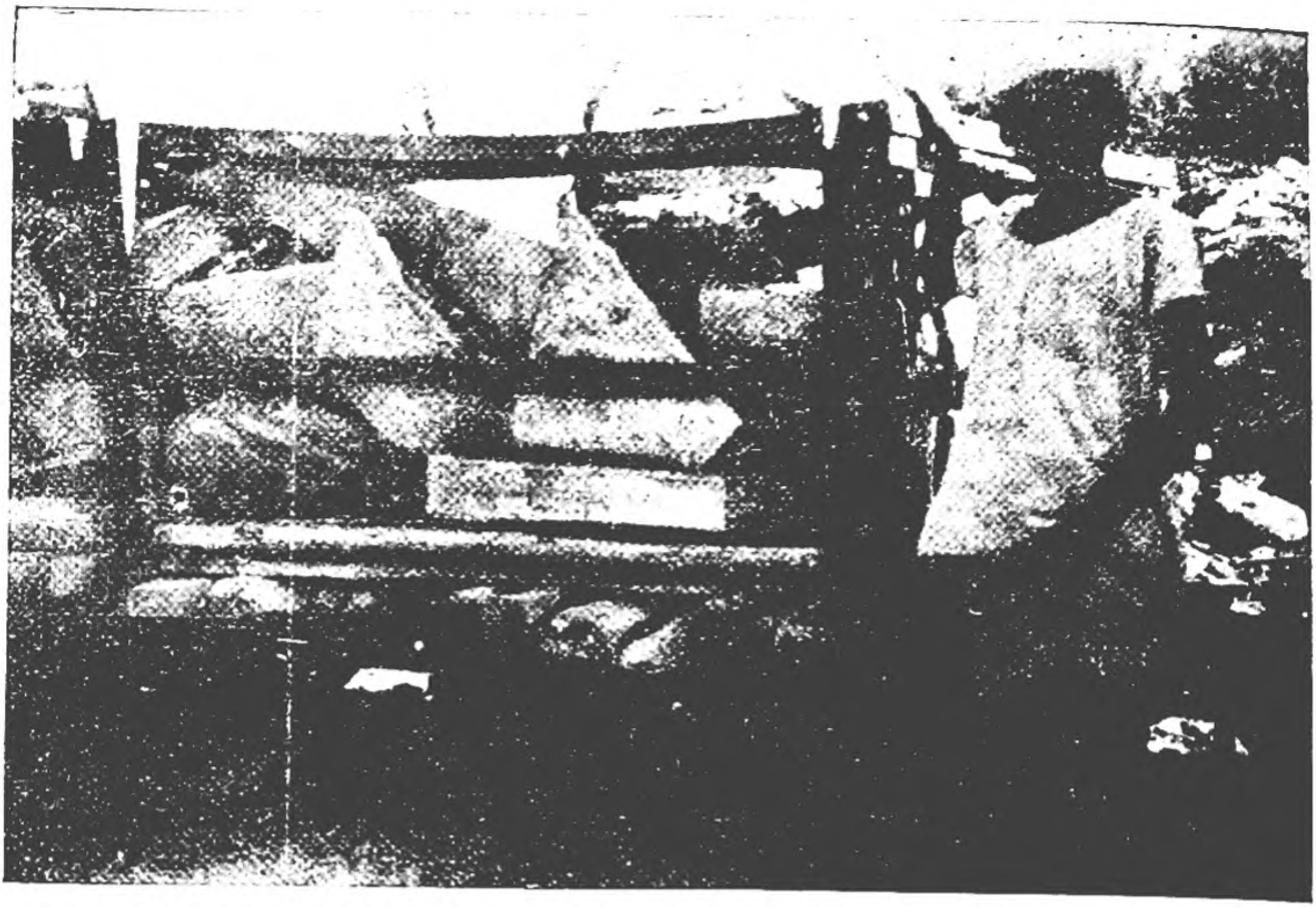


Fig. 1—Showing limestone being transported by the Dehri Light Railway from the quarries to Sasaram. (*Photo: Vishwa Nath Chhibber*).

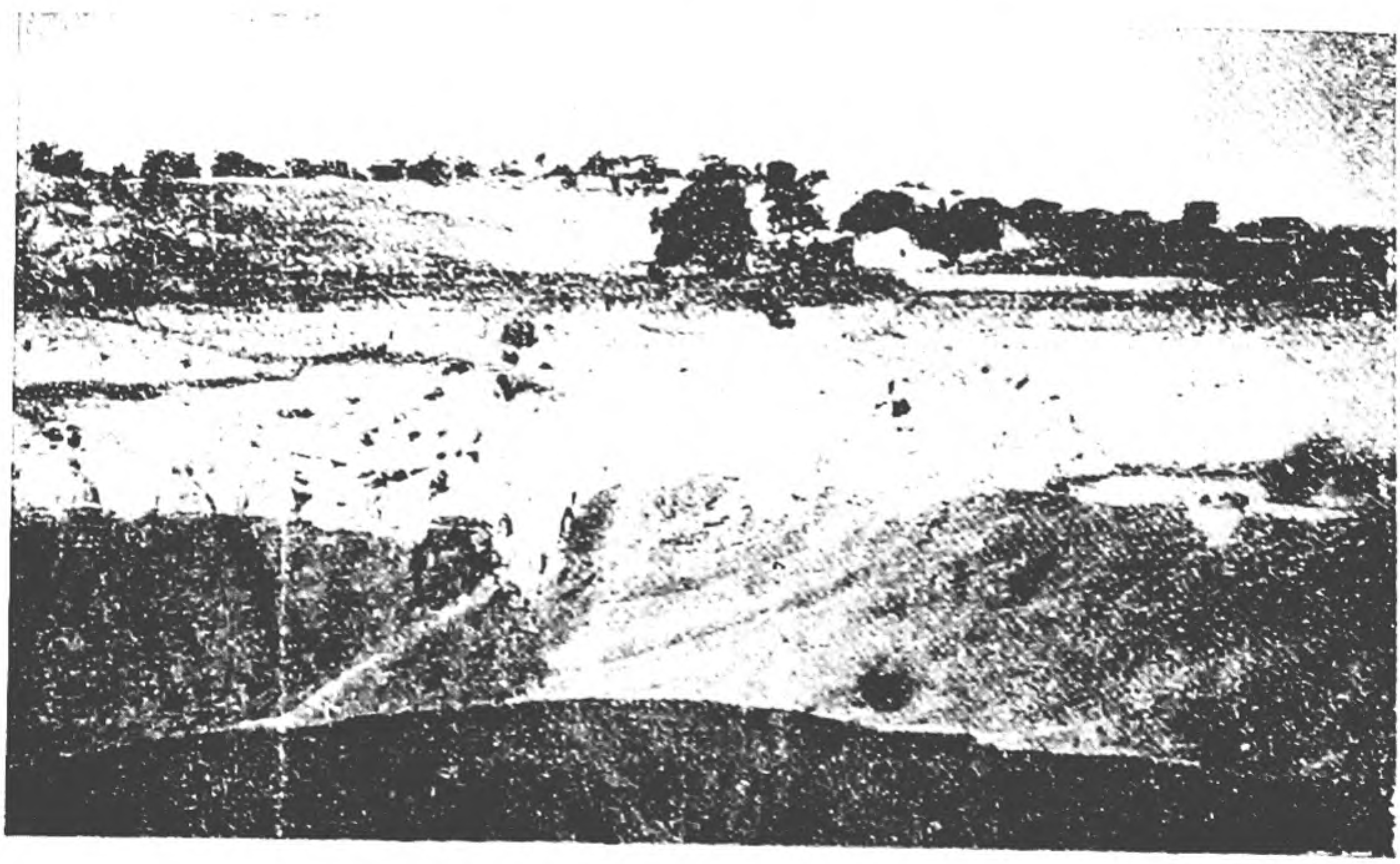


Fig. 2 Showing the Vindhyan Limestone in the North Quarry of the Associated Cement Company at Katni. The limestone is capped by a thick deposit of clay (*Photo: H. L. Chhibber*).

commenced in India in 1914. The industry has made considerable progress owing to its expanding home market due to increased activity in building trades and new uses of concrete. The industry is well established now. There are two varieties : (a) Roman Cement and (b) Portland Cement and in India Portland Cement is largely manufactured, which is prepared by burning pulverised limestone and clay in proportion of three to one in kilns or rotary furnaces. A little gypsum is added to the clinker which is pulverised to make cement. The factories have been chiefly located in the neighbourhood of raw materials, chiefly limestone, but high freight charges on coal for fuel and power have to be paid. About 1.6 tons of limestone makes one ton of cement which contains 38 per cent. coal and 4 per cent. gypsum. Labour is abundant.

Generally, the Vindhyan limestone is used in this manufacture. In places kankar, which is an argillaceous limestone is used in making cement, e.g., at Dalmia Dadri in Jind State. In the factory at Shahabad in the Gulbarga district of Hyderabad-Deccan, flags of Cuddapah limestone are used for the purpose. It may be noted that in India some of the limestones contain all the ingredients in almost correct proportions. At Banmore (Gwalior Portland Cement Co.) the limestone so nearly contains the requisite constituents that very little clay has to be added. At Lakheri (Bundi Portland Cement Co., Ltd.) no clay is used at all, the correct proportion being obtained by mixing different grades of limestone. In other cases substantial amounts of clay have to be added. Gypsum

used to be obtained from Khewra, but with the passing of Khewra into Pakistan, it is obtained from Jodhpur and other Indian occurrences.

On the 1st August, 1936, the various then-existing concerns were merged to form Associated Cement Companies, Ltd. As a result of this merger the Katni Cement Works were changed into Katni Pottery Works because two other factories at Mehgaon and Kymore were working close by. However, today this great cement-manufacturing concern has a network of works operating in various parts of India and recently one more has been added at Jhinkpani near Chaibasa. For this the best type of cement-making machinery was manufactured in their own workshops. In the boom of 1936-37, several new companies were floated, the biggest among them, the Dalmia Cement Ltd. came into existence in 1938. The capacity of the new companies was nearly equal to the production of the Associated Cement Companies, Ltd. The above are the two most important cement-manufacturing concerns, others being the Sone Valley Portland Cement Co. Ltd., Calcutta, the Assam Bengal Cement Co. Ltd, Calcutta and the Andhra Cement Co. Ltd., Bezwada. In 1947, the number of cement works in undivided India was 24, with a capacity of 2,825,000 tons *per annum*. After the partition 19 concerns with a potential capacity of 2,245,000 tons are situated in India. With the sanctioning of the new schemes the total capacity of the Indian Union will be 5.725 million tons. The total capital invested in the industry is estimated at about Rs. 12 crores. Dalmia Cement Ltd.

have established factories at Dalmianagar (Dehri-on-Son), Dalmia Dadri in Jind State, Dandot in Pakistan, Karachi, and Dalmiapuram. In the factory at Dalmianagar, the limestone is obtained from the Rohtas hills in Bihar, while the shale is obtained from Daltonganj at a distance of 50 miles. The cement factory at Dwarka uses miliolite limestone in this manufacture and is one of the largest cement factories in India and its total outturn in 1937-38 was 81,840 tons representing about 8 per cent. of the total production of India.

Consumption and Production :– Although the consumption of cement in India has rapidly and enormously increased, yet the total is much less than what it is in most other countries. In 1936 India's production was about one million tons which was about one eighth of the total world production. During the Second World War the installed capacity was 2,782,000 tons but the actual annual production in 1941-42 was 2,250,000 tons and since 1942 the production has been on the decline. The actual production in tons for the last quinquennium is given below :—

1943	..	..	1, 698, 815
1944	..	..	1, 659, 466
1945	..	..	1, 655, 750
1946	..	..	1, 537, 472
1947	..	..	1, 441, 335

Coloured Cements :– Within recent years coloured cements have been placed on the market which are employed in decoration building work.

Aluminous Cement:–Aluminous cement is a rapid-hardening cement. With abundant resources of bauxite in the country, the production of this cement is likely to be on the increase in India.

Labour:– About 1925 the number of workers employed was 5,000. By 1939 their number had reached 10,000. Today the industry employs more than 25,000. However, a majority of them are not skilled workmen. Their wages are naturally not high, but they enjoy the usual housing, social security and welfare benefits.

In conclusion it may be noted that most of the factories are situated in the interior of the country, i. e., in Northern and Central India to serve the internal demand. With the exception of the works in Kathiawar, Sind and Madras none of them are within short distances of the seaports. The principal market of cement is Bombay and Calcutta. Most of the companies are handicapped to serve these markets on account of distance. There is no cement factory within 350 miles of Calcutta and 250 miles of Bombay. Japla, where the works of the Sone Valley Portland Cement Co. are located is 370 miles from Calcutta. Kathiawar is 260 miles from Bombay, but is handicapped by distance from the coalfields. Thus Indian cement in these Presidency towns has to face severe competition.

It is to be noted that the cement industry has a great future. The demand for cement remains considerably in excess of the supply. Before the Second World War half the consumption of cement was in connection with housing. The partition of the country

has created a new problem of providing housing accomodation for the refugees. The demand by railways,roads, civil aviation and for the making of bridges is bound to increase. A considerable number of irrigation and hydroelectric schemes are in course of consideration. All these will require cement and the Government of India have already sanctioned the additional manufacture of cement to an extent of 1.8 million tons *per annum*.

The present capacity and the proposed extension of the existing and new cement manufacturing concerns together with their geographical distribution is given in tons in the following table :—

No.	Name		Existing capacity	Proposed extension
1	Kymore	(A. C. C.)	2,55,000	1,00,000
2	Khalri	,,	1,00,000	—
3	Wah (Pakistan)	,,	1,73,000	1,00,000
4	Patiala	,,	1,08,000	1,00,000
5	Lakheri	,,	2,25,000	—
6	Gwalior	,,	60,000	1,00,000
7	Rohri (Pakistan)	,,	72,000	1,00,000
8	Okha	,,	1,80,000	—
9	Porbandar	,,	42,000	1,00,000
10	Shahabad	,,	2,00,000	40 000
11	Kistna	,,	84,000	1,00,000
12	Coimbatore	,,	1,80,000	1,00,000
13	Chaibasa	,,	1,00,000	1,00,000
14	Dalmianagar	Dalmia	1,50,000	1,50,000
15	Shantinagar (Pakistan)	,,	2,00,000	1,50,000
16	Dalmia Dadri	,,	60,000	—
17	Dandot (Pakistan)	,,	60,000	1,50,000
18	Dalmiapuram	,,	60,000	1,50,000

No.	Name		Existing capacity	Proposed extension
19	Japla (Sone Valley Portland Co.)		2,00,000	2,00,000
20	Chaatak (Pakistan) ABC.		60,000	75,000
21	Bezwada (Andhra)		30,000	30,000
22	Banjari—Kalyanpur		36,000	36,000
23	Mysore		30,000	30,000
24	Jamnagar			1,00,000
25	Tinnevelly			1,00,000
26	Balsinore	Ahmedabad		1,00,000
27	Mirzapur	U.P.		2,00,000
28	Wun	C.P.		1,00,000
29	Sindhri	Bihar		1,00,000
			26,65,000	26,11,000

Asbestos Cement

In this industry the main raw material is asbestos and the asbestos deposits of India have been described in the foregoing pages. Indian deposits, however, have not been developed to any great extent and this country has to depend upon imports. Before the Second World War, the Asbestos Cement Ltd., Bombay had factories at Bombay, Calcutta and Kymore which used largely Indian cement. The main articles manufactured comprise building sheets, building pipes, gutters, etc. The Second World War provided a stimulus to the industry because of the cessation of imports from abroad. The production of the three factories increased to 6,600 tons per month.

It is considered that two or three new factories could be established in India, without affecting the interests of the existing factories, provided their geographical location is wisely chosen.

Building Stones

The nature of building stones used for building construction depends generally upon what materials are available in the neighbourhood. For instance, in the great Indo-Gangetic plains, building stones and road metal, excepting kankar, are conspicuous by their absence. In this region burnt bricks are largely used for building purposes. In the Himalayan region generally the village hamlets are not infrequently built of stone blocks which are sometimes even roofed with slates or allied material available in the neighbourhood. In Southern India, both building stones and road metal are abundant and are found in great variety. Considering the scope of this work it would be possible to indicate only the nature of the material available together with their geographical distribution in different parts of this great sub-continent. The various building materials have been discussed according to the rock formations in which they occur.

Archaean Rocks

The Archaeans, which comprise the oldest rocks and a concise account of which has been given on pp. 171-173 of Part I of this work, are great repositories of building and ornamental stones. They consist largely of granites, gneisses, etc. which are wide-spread in Peninsular India. The granites, where they happen to be medium-grained, are quarried for building purposes, but sometimes large pillars and columns are carved and polished of these rocks. Examples of such work would

be too numerous, but granite is quarried in the neighbourhood of Jubbulpore, etc. Likewise gneisses or gneissose granites, which sometimes are porphyritic, are dressed into blocks and are used greatly for building construction, especially in North Arcot and Mysore and reveal beautiful appearance on polishing. The Hindu temples of Southern India are built of carved crystalline rocks and on account of their resistant character, the ornate carvings appear as sharp today as when they were first executed several centuries ago. The charnockite rocks are used extensively near Madras. It has been stated that "Kerb stones of Mysore have recently found a market in London in competition with Scandinavian granite[1]."

Outside the Peninsular area, these granites and gneisses also occur in the Himalayas, but they generally occur in somewhat inaccessible regions. As an example, mention may be made of the occurrence of granite-gneiss on which the small hill station of Lansdowne is located. The rock is locally used for building purposes and the Church of Lansdowne is constructed of this rock.

The schists associated with the Dharwar rocks, which in places have developed a remarkable cleavage, are quarried and used as flagstones for flooring purposes. One of the many examples, where schists are put to such a use, is that of Dalpatpur near Tilwara Ghat in the Jubbulpore district.

Cuddapah Rocks

These rocks comprise quartzites, sandstones, slates with associated limestones, conglomerates and igneous

1. *Rec. Geol. Surv. Ind.*, vol. LXX, 1936, p. 362.

rocks. The limestones are often well-bedded and quarried as flagstones, e. g. , in the neighbourhood of Shahabad and these flags along with the slates are widely used for flooring and other purposes in Southern India.

Vindhyan System

Although sandstones are associated with a number of geological formations of India, but those of the Vindhyan System have proved simply superb for building and ornamental purposes. These sandstones, which possess various colours and shades, e.g., red, yellowish-red, greyish-white, fawn, etc. occur both well-bedded and in massive form. The former can be taken out as large flagstones and are used for flooring and other construction purposes. The massive sandstone is quarried in large masses and is used in making pillars, etc. To indicate a somewhat proper importance of these sandstones it may be observed that there is hardly any important building erected in ancient or modern Northern India, particulary in the United Provinces, the Central Provinces and Central India and more specially in the towns of Agra, Mathura and Delhi where the Vindhyan sandstone has not found use. In regard to the extension of the Vindhyas it may be noted that they rise in Gujarat and fringe the southern edge of the Malwa Plateau. They extend further in the Kaimur range and terminate in the Ganges valley near Benares. The rock being medium-grained and compact can stand excellent carving and takes good polish. Examples of such monumental pieces of art and architecture are too numerous to

mention, which have elecited praise from celebrated authors including historians and archaeologists. This sandstone was employed in the B. C. era for inscribing the inscriptions of Ashoka, it was used in raising monumental buildings of the Moguls, like Akbar's palace at Fatehpur Sikri, the Jumma Masjid and portions of the Taj Mahal. In the present century this sandstone has been employed in building New Delhi, the capital of India.

It may also be noted that this sandstone forms an excellent road metal. In the Mirzapur district for instance, quarries are located all along the Vindhyas and the sandstone, apart for building purposes, is broken into road metal and railway ballast, used so largely in the adjoining plains.

Vindhyan Limestone:– With the Vindhyans, limestones are also associated, which on account of their purity have acquired great fame for their lime-burning purposes. Satna lime is not only utilised in building construction, but finds great use for various chemical purposes.

Katni in the Jubbulpore district, Central Provinces, is another important limestone and lime-producing centre. The limestone belongs to the Vindhyan System and is raised from a number of quarries, several of which are situated along the Mirzapur road. The limestone here has apparently been reduced to a peneplain and is quarried from flat ground underneath the soil. The average annual production of limestone during the quinquennium 1929–33 was 338,177 tons valued at Rs. 3,95,974.

Large quantities of limestone are also quarried from the Vindhyas by several concerns in the Shahabad district of Bihar and the Dehri Rohtas Light Railway was constructed for its transportation. Not only this limestone is used for burning lime, but it is also used in the manufacture of cement. The average anuual production of limestone in this district during the quinquennium 1929–33 was 233,442 tons valued at Rs. 4,14,936.

Other Sandstones

Sandstones of Gondwana age have been used in parts of Bengal, Bihar, Orissa, the Central Provinces, etc. In Cutch Jurassic sandstones are abundant and have been extensively used there.

Deccan Trap

Another important formation, which has yielded both good building stone and road metal is the Deccan trap comprising basaltic lava. It occupies an area of 200,000 square miles covering parts of Western and Central India, the Central Provinces, Bombay and the Deccan. This rock can be easily broken and dressed into blocks which are used in building construction, bridges, etc. Although the colour is black and not pleasing to the eye, the rock is very durable. A light-coloured variety of this trap, has been used in building the Gateway of India.

Likewise other trap rocks of India are used extensively as building stones and road metal. The Panjal trap in Kashmir is quarried at suitable places for this

purpose. Similarly the Rajmahal trap has been quarried for hundreds of years and has supplied road metal to Calcutta and material for river training works on the Ganges.

Nummulitic Limestone

Limestones of various ages have been used in building construction. Permo-Carboniferous limestone and Nummulitic limestone in the Salt Range and elsewhere find use for building and ornamental purposes. They are also used for burning lime and large quantities of this limestone are collected as scree or detrital material, particularly in the Jhelum district of the Punjab. The Nummulitic limestone of Assam, quarried from the southern scarp of the Khasi and Jaintia hills, is brought by boats during the rains to Sylhet, where it is burnt to lime.

Porbander Stone

Miliolite, a fine-grained white or buff limestone of Recent origin, also known as Porbander stone, is quarried along the western base of the Barda hills in Kathiawar. It is used extensively in Kathiawar, Bombay and Karachi.

Kankar

Kankar is the name generally given to concretions of impure earthy limestone occurring in the Indo-Gangetic alluvium, particularly in the older Alluvium. It may be noted, however, that the occurrence of kankar is confined not only to the Indo-Gangetic alluvium, but it is also found in the alluvium of other rivers, e. g.,

the Narbada, etc. The kankar is invariably interstratified with this alluvium at different levels. It occurs in beds or lenticular patches with thickness varying from a few inches to several feet. It is dug in lumps, which on exposure to the sun, harden. Kankar is generally dug to shallow depths, but in cliff sections, e.g., those bordering the river Ganges, say near Benares, Mirzapur, etc. its intercalations or lenticles are repeated and sometimes several layers are observed to a depth of 50, 60 or even 100 feet from the surface. The base of kankar like that of the alluvium has not yet been known. It sometimes occurs in the form of massive block kankar, which is employed to a certain extent for building purposes, otherwise concretions of kankar possess all kinds of fantastic shapes. Occasionally, it occurs in the form of veins. It may be observed that several varieties of kankar based on structure and colour of concretions are recognised locally, e. g., *Bichhua*, *Gathia*, *Matmaila*, *Chawan*, *Patharia*, etc. In various specimens chemically analysed, percentage of carbonate of lime has been found to vary from 54 to nearly 80 per cent.

In the alluvial plains kankar is still largely used as a road-metal, ballast for railway lines and for making concrete for foundations and floors. It is also burnt to manufacture hydraulic lime. It has been employed in the manufacture of cement and attempts are again being made to manufacture cement from kankar, particularly where it is found as massive block kankar, e.g., near Ajgain between Unao and Lucknow. Kankar is quarried particularly in every district of the plains as this is the only somewhat hard stone available there.

It may be noted that in the United Provinces, more than half a million tons of kankar are utilised *per annum* and the total annual output in India is placed at a conservative estimate of 2,500,000 tons.

Laterite

Laterite, which is used both as a building stone and a road metal occurs very wide-spread in Peninsular India. This rock, which is dark brownish or yellowish-red in colour has the special advantage that when freshly dug it can be easily cut into blocks which harden on exposure to air. Laterite is derived from a number of rocks, e.g., the Deccan trap, granite-gneiss, khondalite, limestone, sandstone, etc. These rocks have a wide distribution in the Deccan, particularly the first two and wherever the hills are flat-topped, they are generally capped by laterite. It has already been noted in the foregoing that numerous flat-topped hills composed of granite-gneiss in the Ranchi district of Bihar possess very large reserves of laterite. It is seen capping bauxite. In places it forms very steep escarpments. Sometimes it forms a hard pan with characteristic rough vesicular appearance. When specially rich in iron, this rock has been used as an ore of iron by indigenous smelters. Red or yellowish-red ochres are also associated with laterite.

Slates

Slates are quarried in the Himalayas, Rajputana, Bihar, Madras, Bombay and Gwalior. In the Himalayas they occur around Dharmasala in Kangra, Chamba, Garhwal and Kumaun. The slates also form the south-

ern flanks of the Dhauladhar range, but on the whole they form good roofing material as in some cases the rock is only a hardened phyllite, e. g., near Dogadda and Lansdowne in the Garhwal district the phyllites have become hardened and rendered slaty by an intrusion of the granite-gneiss.

Slates are also quarried in the neighbourhood of Rewari, Gurgaon district of the East Punjab. According to Dr. A. M. Heron they are hardened shales and thin films of iron oxide occur along the bedding planes, but an excellent band occurs at Kund near Rewari, where the Kangra Valley Slate Company, Ltd. has been working for several years. The roofing material can be cut to a thickness of one-eighth of an inch and the slates are available in all sizes.

Slates also occur in the Kharkpur hills in the Monghyr district of Bihar and have been worked on a large scale for a long time. The rock is a somewhat metamorphosed phyllite and yields fine slabs which can be employed for flooring, terraced roofing and electrical purposes. Another locality, where slates are found, is the Singhbhum district of Bihar.

Slates occur in the Cuddapah district of Madras, in the Panch Mahal and Bijapur districts of Bombay and in Gwalior State. The production for the year 1944 was 6,346 tons valued at Rs. 1,64,954. It may be noted that in this production the Punjab's share alone was 5,961 tons.

Production and Imports

The production of building stones and road metal in India, together with their value, is given below for the year 1944 :–

	Tons	Value in Rupees
Granite	1,633,563	30,69,967
Sandstone	395,502	12,21,651
Trap	6,595	11,891
Limestone and Kankar	5,218,100	1,19,01,146
Laterite	795,528	1,31,383
Misc. Building Stone and Road Metal	5,704,820	57,04,483

It will be seen from the above figures that during 1944 India produced building stones and road metal of the value exceeding rupees two crores and twenty lakhs.

With regard to imports, India imported building and engineering materials from abroad of the average annual value of more than one crore of rupees during the years 1928-29 to 1932-33 in addition to stone and marble of the average annual value of Rs. 5,33,924. The material included in the above trade statistics comprises asphalt, bricks and tiles, cement, chalk and lime, clay and earthenware piping. It may be noted that the average annual quantity of cement imported during the above period was 106,219 tons valued at Rs. 51,21,344.

In conclusion it may be stated in the words of Cyril Fox and Misra[1] : "on the whole it may be said that the Indian resources in road and building stone as well as stone for lime, cement, concrete, etc., have not been utilised to the degree that the supply could easily provide for."

1. *Rec. Geol. Surv. Ind.*, vol. LXXVI, 1947, p. 6.

CHAPTER XV

Conservation of Mineral Resources and National Mineral Policy

Having given a brief account of the important mineral deposits of India, it is necessary to point out about the conservation of the mineral wealth of the country. Minerals, which play such an important role in national economy of a country, are vanishing assets. Their efficient use is, therefore, a matter of vital national concern and the greatest attempts are being made in every country to affect as much conservation as possible by eliminating all possible was tageto prolong the life of the deposits. The question of conservation of coal and mica has been referred to in appropriate places.

The present writer believes it to be the duty of everybody concerned to bring to the notice of the public wherever any avoidable wastage of mineral wealth may be occurring. He has noticed some glaring examples and a short note was contributed on the Conservation of the Mineral Wealth of India in *Current Science*, vol. 15, 1945, pp. 124-125 and the following account is based on it.

In quarrying limestone near Katni in the Jubbulpore district, a great overburden of clay, about 40 feet in depth has to be removed. This clay is mainly whitish with reddish, brownish, yellowish and greenish streaks in places. It is already being used in the Katni

Pottery Works. But what was noticed in Bajan and Company's quarry and, in fact, in many other quarries was that good clay along with the dark-coloured soil was being dumped in the adjoining fields. Evidently the clay on being mixed with the dark-coloured soil and so dumped is rendered impure. The overburden being huge, thus very large quantities of the clay are wasted. In places 'hillocks' of this material are to be seen, which as a result of erosion by heavy and torrential rainfall during the monsoon season show deep ravines on their sides. First the clay is rendered impure and secondly it is allowed to be washed away freely by rain when it could be put to good and profitable use.

In the neighbourhood of Katni it was also found that good iron ore was being used as road metal and literally numerous stacks of this mineral were still lying along some of the roads. It is good, hard brownish black limonite with about 59 per cent. of iron. It may be noted that limonite deposits in Lorraine and Luxemburg constitute the most important iron ore deposits of Europe. Besides being an ore of iron it is also used as a yellow mineral pigment. But in the neighbourhood of Katni, its use as a road metal was indeed surprising, particularly when unlimited resources of road metal from the Vindhyan sandstone and limestone occur in the same area.

The writer was informed by Mr. Govind Prasad Sharma of Katni that barytes of good quality has been used as ballast on the railway line near Rupaunda railway station, while again unlimited quantities of the

Vindhyan rocks are available for the purpose only a short distance away.

Barytes, which is sold to the paint works of the New Industries Ltd., Katni was observed to contain very good fluorspar, violet in colour, but it was sold with the barytes making it an off-colour second quality. Fluorspar is a mineral in demand in India by the Steel and Aluminium works. It also finds a number of other important uses. It certainly deserves to have been separated, thus raising the price of both the barytes and the fluorspar.

Fire clay is being quarried a little more than half a mile north-west of Bhaganwara, which is about 5½ miles north-west of Sleemnabad Road railway station on the Katni-Jubbulpore line. The method of working this deposit is that a pit is dug for extracting the clay. With the advent of rains, the work is stopped and the deep pit naturally gets filled with water. Next year the old pit remains abandoned and a new site is chosen. This process is repeated and today several deep pits and tortuous channels filled with water are to be seen. This procedure indeed tends to spoil the deposit and is certainly not conducive to the conservation of the important deposit of fire clay, a material greatly in demand for manufacturing refractories. It would be indeed unfair and unprofitable to future working as the water will have to be baled first and then work will have to be carried out in deeper portions. With regard to the depth of the deposit, a deep pit to a depth of 80 feet was sunk, but it did not touch the base of the clay

deposit. The systematic procedure to work this deposit would be to commence from one end and to win all the clay to the base of the deposit.

These cases have been placed before the public in order to make us more conservation-minded with regard to our mineral deposits as once a mineral is lost, it is irreplenshible. It has been suggested that the companies should not be allowed to work a mineral deposit if they do not affect maximum extraction. Again, B. Rama Rao[1] has aptly said : "the reprehensible practice of scooping out only the best and the most easily accessible portions of the deposits leaving the rest untouched, would lead to the rapid depletion of most of our economic mineral resources as it has already happened in the case of manganese ore and mica .... Consequently to get the utmost of any deposit, scientific development and intelligent mining and proper utilisation are absolutely essential and should be insisted on by the State." Dr. C. Forrester[2] has emphasised on "the prevention of waste or what might be called abuse of mineral riches."

National Mineral Policy

The key industries of a nation depend upon mineral raw materials. Some of the minerals have great strategic importance in manufacturing armament and ammunition. Although water power is being increasingly

1. Mineral Policy for India, *Bulletin* No. 6, *Geol. Min. Met. Soc. Ind.*, 1943, pp. 19–20.

2. Comments on Mineral Policy, Bulletin No. 6, *ibid.*, p. 9.

developed, wherever possible, yet some of the mineral fuels like coal and petroleum still remain important for industry.

Conservation of mineral wealth falls under two heads : first maximum extraction and secondly proper and efficient utilisation of minerals of economic importance. What has been stated above about the conservation of India's mineral wealth should indeed be the first step in the mineral policy for India. Naturally, the deposits should be worked in such a way that the maximum percentage of the reserves of these minerals should be available in the interest of everybody directly concerned and the country in general. In fact wastage should be stopped by legislation. This is all the more necessary in the case of important economic minerals occurring in limited reserves. Expert committees like Coalfields and Mica Enquiry Committees should be appointed to go into the question of proper conservation of minerals.

Research and Proper Utilisation :— On pp. 173–174 of this work the reserves of iron ore in the Singhbhum district of Bihar and the adjoining Eastern States as given by H. C. Jones have been cited, although he considered that the actual reserves may be more than twice. Recent research work carried out by F. G. Percival[1] has shown that the reserves of the iron ore may be of the extent of 8,000 million tons rather than 3,000 million tons. The same author has

1. Estimated Reserves of Iron Ore in the Singhbhum-Orissa Field, *Trans. Nat. Inst. Sci. India*, vol. II, 1947, pp. 373–375.

further concluded : "Later discoveries of deposits below alluvium, at present unknown, may necessitate an increase on this estimate in future." The present author intended to emphasize the value of research work by citing this instance. In case of mineral investigation, work, both in the field and laboratory, will have to be carried out.

In the proper utilisation of minerals, latest methods of ore dressing, concentration and metallurgy should be applied. In this the research organisation of the country like the Board of Scientific and Industrial Research or the newly instituted Bureau of Mines should carry out research to assist mining and manufacturing concerns. Methods of beneficiating the low grade ores of useful minerals like copper, chromium and manganese, etc. should be investigated in order that they may be utilised in developing suitable industries.

Considerable sums of money are spent in foreign countries in advancing their mineral industries. There is no reason why India should lag behind. Research should be sponsored both by the public and the private organisations. The industry itself should take a very tangible part in furthering its advancement. Examply of a Ford, a Carniege, or a Nuffield have been aptly cited from foreign countries in this direction. Improvement and expansion of industry can only be affected by research.

Planning :— Planning in mineral industry is indeed a very important factor. Centres of industrial development should be carefully selected, keeping in view the

proximity of raw materials, available power, transport and marketing facilities as the distance involved in bulky transport of minerals and those of manufactured goods to markets should be reduced to an absolute minimum.

Export of Minerals :— There is practically unanimity of opinion that export of all minerals in raw state should be discouraged as far as possible. In this connection Dr. D. N. Wadia[1] has aptly stated : "the gravest defect of the present-day mineral industry of India is that by far the largest quantity of the produce of our manganese, mica, chromite, ilmenite, refractory and some other minerals are extracted mainly for the purpose of the export trade and at a rate which will in course of but few years deplete the reserves of valuable key metals and accessory minerals.

"The bulk export of raw materials even when they are in large excess, without processing or treatment deprives the country of the major share of the ultimate profits of the finished commodity.... India was conceived of as a natural *depot* of raw materials for the workshops of foreign countries.

"More than 20,000,000 tons of high grade manganese ore has left the country during the 30 years preceding the war, the price obtained for it being absurdly low. At this rate of export it is possible that at some future date, when India has begun to utilise to the full her metallurgical resources in steel manufature, she may have already wasted her valuable asset to such an extent

1. *Op. Cit. Sup.*, pp. 15–16.

that she will have to import manganese from overseas at several hundred per cent. premium over the price she is receiving today for her outward shipments."

Minerals should be processed or semi-fabricated as far as possible. This would provide employment for skilled work in the country and would bring higher return for the minerals. Sometimes it is argued that reserves of a particular mineral, say iron ore, are particularly great and so we must export. In this connection Dr. C. S. Fox[1] has rightly shown that if India exported her iron ore, the price at the quarries would be about Rs. 2 per ton. But if the same ore were reduced to pig iron, the value would be Rs. 48 or even more per ton. If steel is manufactured, the amount received will be still greater. Besides iron and steel industry will develop in the country. Such instances could be multiplied and that of manganese has been cited above. Dr. J. A. Dunn[2] has gone to the extent of saying : "the mining of certain deposits may be even better held up for a while until related industries which can use the minerals in the country are developed." Certainly nobody could recommend the export of key minerals like chromite, magnesite and other refractories, etc.

Cheap Transport :– Minerals, particularly the ores are heavy and cheap transport should be provided as far as possible for ores and fuels. Now that the railways are state-owned, and railways stand to play a great part in the development of mineral industry,

1. *Indian Finance Annual*, 1946, p. 70
2. *Proc. Ind. Sci. Cong.*, Benares, 1941, Part IV, p. 60.

special rates could be provided for the transport of minerals required in industry. It would provide impetus to industrialisation. Water transport should be cheap and developed as far as possible. By developing this kind of transport on the Ganges and its tributaries, heavy goods can be transported cheaply over long distances. For instance goods from some stations, say on the Gogra or any other important tributary of the Ganges in the United Provinces, can be carrried as far as Assam. In difficult regions aerial transport like aerial ropeways should be developed as far as possible. Some minerals like corundum and sillimanite occur in Rewa and some refractories occur in difficult regions of Assam. No doubt these deposits should be opened up by providing easy means of communications and transport.

Cheap Water Power:– Cheap water power is absolutely essential for proper industrialisation. India fortunately possesses unlimited potential resources of water power. It is surprising why these cheap power resources have not been developed fully yet. It is gratifying to observe, as discussed later, that the Government is now trying to develop some multipurpose schemes. The development of cheap water power will help in the establishment of industries away from the coalfields of Bengal and Bihar.

State Help and Tariffs:– An industrialist once defined state help as the foundation of industry. There is no doubt that state help must be forthcoming against unfair competition like dumping, etc. from abroad.

the Government help and protection must be available, wherever necessary. Again suitable tariffs will have to be imposed on the export and import of minerals. Naturally, in case of minerals and metals, in which the country is deficient, duty-free minerals will have to be imported.

In conclusion it may be stated that in case India's industry is to undergo expansion, scientific and systematic development of her mineral resources is absolutely imperative. The policy of the Government should be to encourage further development of mineral industries. This will assist in the proper utilisation of raw materials.

Development of Mineral Industry

In passing, a word about the advancement of mineral industry may not be out of place. It has already been stated that mineral industry has been aptly styled as the key or the basic industry. Our iron and steel industry may have been well established, but it has been rightly pointed out that there are so many mineral products imported, which can be manufactured easily in the country with our raw materials.

In brief it may be pointed out that there is a great scope for development of industries using the following raw materials : asbestos (mineral wool), barytes, various kinds of china and refractory clays, felspars, gypsum, kyanite, limestone, magnesite, marble, mica, mineral pigments, mineral waters, nitrates, phosphates, quartz, *reh*, sodium and alkali compounds, steatite, the manufacture of sulphur and sulphuric acid from pyrites and

other sulphides and finally thorium representing an important source of atomic energy, which is associated with monazite. The proper importance of some of these minerals has been hardly realised in the country. It has been suggested that artificial abrasives, e. g., silicon carbide and fused alumina can be manufactured in India. A. L. Ojah[1] has suggested : "abrasives and polishing materials such as silica, garnet, corundum, lime, talc and magnesia can be produced in the country in large quantities not only for our own consumption, but even for export." Not only great reserves of bauxite can be used for smelting aluminium, but it can be manufactured into a host of industrial products and an important by-product is titanium dioxide, which can be used in the manufacture of pigments. Likewise, the manufacture of bichromate and other salts and ferro-chrome alloys from chromite could be undertaken. Although our glass industry is well established, yet optical glass and the manufacture of lenses has not been undertaken. The manufacture of micanite, when both mica and shellac are available, should be developed on a proper scale. It may be noted that these are some of the lines indicated. There is indeed a great scope for research for a great industrial development based on the utilisation of India's minerals. It may also be noted that the development of some of the above industries would not need even great capital and would offer employment to the educated youth of the country.

1. *Op. Cit. Sup.*, p. 25.

CHAPTER XVI

Power and Fuel Resources of India

Coal, petroleum, natural gas and water power represent the most important fuels. The first three are not only used directly as fuels, but are also converted into power indispensable for industry.

Coal

Coal is an important fuel and chief source of power and before the development of water power the industrial development of a country was generally measured by the amount of coal consumed and the industries began to be located on or near the coal-fields.

Coal mining from the point of view of output by weight, value and number of workers employed represents the most important mineral industry of India. India is now an important coal-producing country and meets her own internal demand.

Giridih coalfield was the first to be discovered and was systematically worked between the years 1870-80 when half a million ton of coal was raised annually. Jharia was connected with railway in 1893. Other fields were opened with the development of other railways.

In 1919 India's output was $22\frac{1}{2}$ million tons and this figure was reached again only in 1928, the decline being naturally due to post-war causes In 1938 her out-turn was 28 million tons. Of this output nearly 89 per

cent. came from the coalfields of W. Bengal, Bihar and Orissa, 5.5 per cent. from the Singareni coalfield of Hyderabad-Deccan, 3.5 per cent. from the Central Provinces and 1 per cent. from the Umaria coalfield in Central India. This gives the geographical distribution of coal. Thus about 98 per cent. of coal is produced from the Lower Gondwana coalfields of Peninsular India; the remaining is from the Tertiary coalfields of Extra Peninsular region.

In India coal is mainly obtained from coalfields of two distinct ages :

(1) The Gondwana.
(2) The Tertiary.

The latter source constitutes less than 2 per cent. of the total output and comprises the coalfields of Assam, Rajputana, Baluchistan and the Punjab. Their output in tons for the year 1936 and 1937 is shown below :

	1936	1937
Gondwana coalfields	22,212,457	24,571,343
Tertiary coalfields	398,364	465,043
Total	22,610,821	25,036,386

The output of coal from the Gondwana fields during 1937 is given below :

	Tons	*Percentage of Indian Total*
Bengal, Bihar and Orissa		
Bokaro	2,309,170	9.22
Giridih	674,794	2.70
Jainti	47,490	0.19
Jharia	9,601,230	38.19
Karanpura	534,328	2.14
Rajmahal hills ..	1,201	0.01
Rampur	47,127	0.18
Raniganj	7,196,324	28.74
Central India		
Sohagpur	251,035	1.00
Umaria	83,256	0.33
Central Provinces		
Ballalpur	264,269	1.05
Pench Valley ..	1,234,233	4.93
Shahpur	5,657	0.03
Eastern States Agency		
Korea	850,701	3 39
Raigarh State ..	2,500	0.01
Hyderabad-Dn.		
Kottagudem ..	1,176	0.01
Sasti	68,671	0.27
Singareni	740,770	2.96
Tandur	265,624	1.06
Total	24,179,556	96.41

The average provincial output for the years 1936 and 1937 is given below :—

Province	1936	1937
Assam	203,239	248,563
Baluchistan... ...	8,099	17,479
Bengal*	6,667,841	6,527,820
Bihar	12,016,914	13,836,717
Central India ...	329,488	334,291
Central Provinces ...	1,507,982	1,504,159
Eastern States Agency	804,432	1,244,988
Hyderabad-Dn. ...	852,739	1,076,241
Orissa ...	31,061	47,127
Punjab* ...	156,849	166,632
Rajputana ...	30,177	32,369
Total	22,608,821	25,036,386
Value in rupees	6,24,98,404	7,81,023,439

It has been deemed advisable to group and describe the coalfields of India according to their age and geographical distribution.

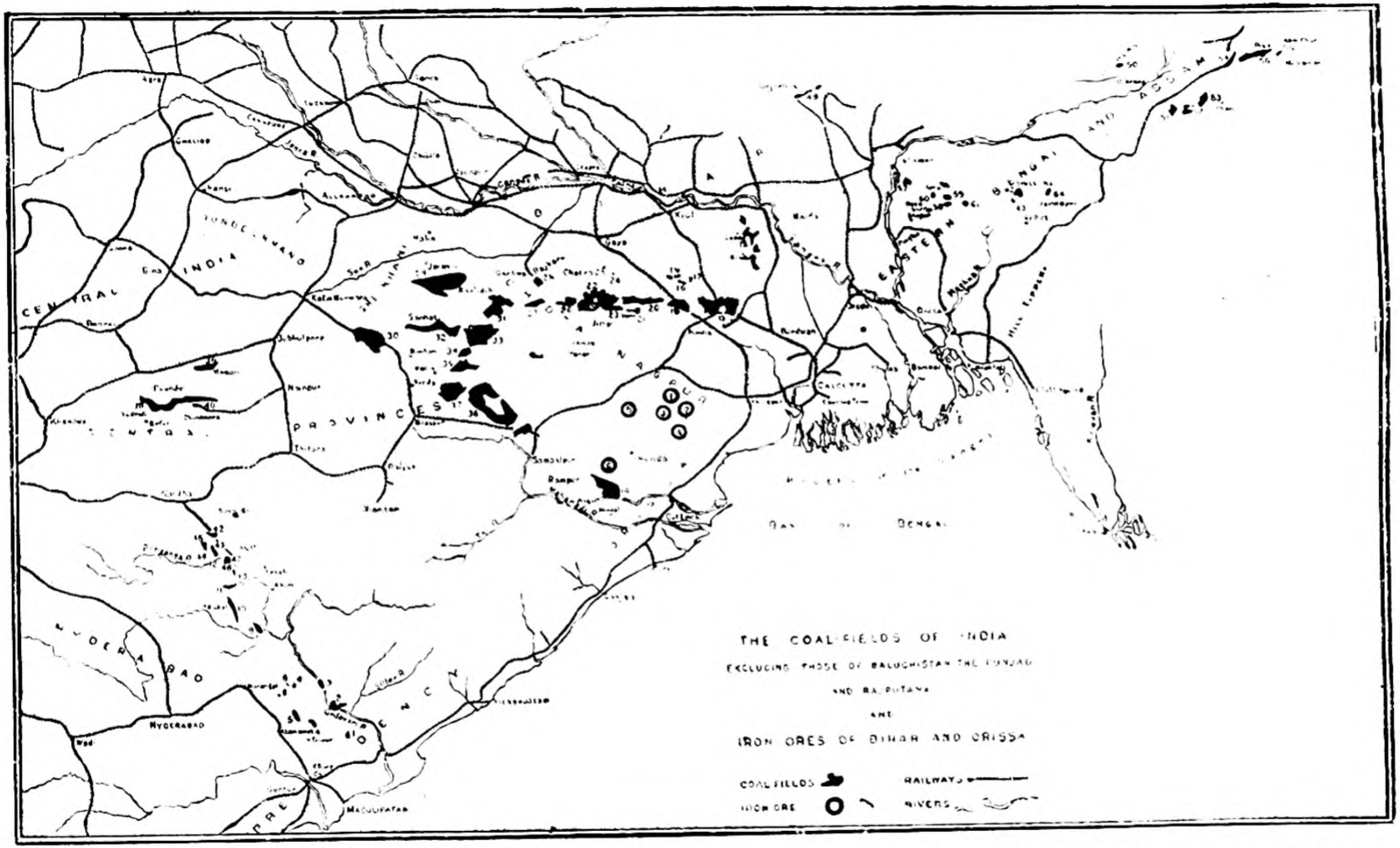
Gondwana Coalfields

Important Gondwana coalfields, listed above, occur along the valleys of the Damodar, the Mahanadi, the Godavari and the Wardha rivers.

It will be observed from the above table that although a number of coalfields occur in this group, but

* Since the partition of India, Bengal has been divided into West and East Bengal, the latter becoming a part of Pakistan. Likewise the Punjab has been divided into the West and the East Punjab. The coal in question occurs in West Bengal and the West Punjab.

PLATE XXX. To face page 308.



Showing the disposition of the Coalfields associated with the Gondwana deposits. The position of the important iron ore deposits in Bihar and Orissa is also shown.

there are only three important fields, viz., Jharia, Raniganj and Bokaro, which yield more than 75 per cent. of India's output.

Bengal, Bihar and Orissa

Nearly 90 per cent. of the production of coal comes from the coalfields of these provinces. These coalfields represent isolated fragments which once formed a band stretching east-west along the Damodar valley and were preserved by faulting into the old crystalline rocks.

Raniganj Coalfield :– This coalfield, 120–150 miles north-west of Calcutta, forms the easternmost coalfield of the Damodar valley and has an area of 600 square miles. However, the total proved area occupied by the Damuda series is about 420 square miles. It is the premier coalfield in India and was worked as early as 1777 and remained the leading producer until 1905. In the year 1906 its output, which was 37 per cent. of India's total, was exceeded by that of Jharia with 42 per cent.

Its Lower Gondwana rocks are divided as follows:—

Panchet series
Damuda series
Talchir series

The Damuda series, which is coal-bearing, is classified as follows :–

3. Raniganj stage
2. Ironstone shales
1. Barakar stage

The Barakar stage and the Raniganj stage carry thick seams of coal. A number of mica-peridotite and dolerite

intrusions are found in the western and middle portions of the coalfield and have caused great damage to some of the best seams of coal.

Jharia Coalfield :– This coalfield occurs about 30 miles west of the Kaniganj coalfield. Mining was commenced here in 1894 with the extension of railway. It occupies an area of 175 square miles. Its maximum production in 1919 exceeded 12 million tons, representing over 53 per cent. of India's total for that year. The total thickness of coal seams is over 200 feet, while the workable portion is considered to average 75 feet in the eastern half of the coalfield. As in Raniganj coalfield intrusions of mica peridotite and dolerite occur, but the former are more predominant. They have been responsible for converting many million tons of good quality caking coal into *Jhama* (partially coked coal).

Bokaro Coalfield :–This coalfield lies in the catchment basin of the Bokaro river and extends for 40 miles in an east-west direction and 7 miles in a north-south direction. The eastern portion of the field is more important and the railway collieries have been responsible for its rapid development. It has an area of 220 square miles. The through railway communication was established with this field in 1919. There was a record production of over 2 million tons in 1930, which represented 9 per cent. of India's production for that year. There are some seams of good caking coal and the reserves are estimated at 600 million tons.

Karanpura Coalfields :–These coalfields, which occur in the Upper Damodar Valley comprise North and South Karanpura coalfields, the former comprises an area

of 472 square miles, while the latter has an area of 75 square miles. The reserves of both these coalfields are estimated at 9,500 million tons. Production commenced in 1925 and soon the output reached 2 per cent. of India's total. It is a good steam coal and is known to yield a fairly hard coke. These coalfields are considered to have a bright future.

Giridih:–This coalfieid is also known as Karharbari coalfield and lies in the Hazaribagh District of Bihar. Although this coalfield occupies an area of only 11 square miles, while the area covered by productive measures is 7 square miles, yet it occupies an important position and produces some of the best coal in India. Systematic mining commenced in 1851. It was connected with railway in 1871 and mining has been active ever since.

The coal ha- a high calorific value. The lump coke is used on the Indian railways, while the powdery coal is converted into coke.

The estimated reserves in 1928 were 60 million tons. The Lower Karharbari seam, with a thickness varying from 10 to 24 feet and which represents half of the above reserves, yields best coke. In 1919 the output was slightly under one million tons which constituted about 4 per cent. of the year's production.

Aurunga, Hutar and Daltonganj:—These coalfields represent an extension of the Damodar Valley on to the west in the Palamau district of Bihar. They lie north and south of Daltonganj within the catchment of the north Koel river.

The Aurunga coalfield has an area of 97 square miles. There are numerous coal seams, some of which attain considerable thickness, but the coal exposed is of inferior quality.

Hutar coalfield lies 12 miles west of Aurunga and has an area of 57 square miles. Several seams having an individual thickness of 12 feet occur in the Barakar rocks and the coal is said to be of average quality.

Daltonganj coalfield has an area of 32 square miles. Coal was found in 1829, but actual mining commenced soon after 1840 and it was connected with railway in 1901. Several seams of medium thickness are known to occur, but the coal is non-caking and the quality is reported to be not good.

Talchir :—This coalfield lies in the Mahanadi belt and is about 65 miles north-west of Cuttack. It occurs, in the Brahmini Valley in Orissa. It covers an area of about 200 square miles and the reserves have been estimated at 184 million tons. It is noteworthy that this coalfield is nearer Madras presidency, where its coal is naturally likely to be utilised. Production commenced in 1923 and the peak production slightly exceeded 250,000 tons.

Central India

In Central India more important coalfields of Singrauli, Umaria and Sohagpur occur

Singrauli Coalfield:– This coalfield lies south of the Son river in Rewa State and on the borders of the Mirzapur district in the United Provinces. The

coal-bearing rocks occupy an extensive area of about 900 square miles. A number of coal seams occur of which the Parari, 6 feet in thickness, and Naunagar 18 feet in thickness, are promising. The latter seam alone is calculated to contain an average of 15 million tons per square mile. The importance of this coalfield is likely to be enhanced with the laying of the projected Central Coalfields railway.

Umaria Coalfield:– This coalfield occupies only an area of about 6 square miles, but on account of its situation on the Katni-Bilaspur line has attracted considerable attention. The coal is known to contain a high moisture and ash content. The estimates of the total reserves made by different experts appear to vary up to 80 million tons. It was first exploited in 1882 and has yielded a production of $6\frac{1}{2}$ million tons since that year.

Sohagpur Coalfield:– The coal-bearing rocks occupy an area of about 1,200 square miles. In fact such rocks continue into Korea State and the total area is 1,600 square miles. Several coal seams having a workable thickness and a promising quality are known to occur. This coalfield will prove of great value with the improvement of railway communications. Mining commenced in 1921.

It may be observed that all these coalfields represent only the exposed portions of the coal-bearing rocks which are considered continuous underground from Singrauli to Sohagpur. A systematic exploration of this region along with the development of the commu-

nications has been advocated. The reserves of coal in this region are considered to be immense. The quantity after deductions for barren areas and loss in extraction is roughly estimated at 4,000 million tons. For a more detailed information the interested reader is referred to Dr. C. S. Fox's "The Mineral Resources of Rewa State" published by Rewa Government.

Central Provinces

The coalfields of the Central Provinces can be divided into three groups :— (1) Chattisgarh region, (2) Satpura Basin and (3) the Wardha Valley. A concise account of the coal-bearing areas of these regions is given below.

Chattisgarh Region

Many coal-bearing areas occur in this region, but most of them lie undeveloped. These areas actually represent exposures of Barakar coal seams in an extensive Gondwana area. The lava flows of the Deccan trap and allied intrusive rocks occur in the region. A brief account of the various coal-bearing areas will be found in the sequel.

Tatapani-Ramkola Coalfield:–This coalfield is situated in the north-west of the Sirguja State, but it actually lies at the eastern extremity of the Damodar valley. The Barakar rocks occupy an area of 100 square miles. Several seams occur, but the coal is not of good quality.

Kurasia Coalfield :– This coalfield, occurring about Kurasia village, occupies an area of 48 square miles and is considered promising. With the advent of railway

communications in recent years collieries have been developed. Several coal horizons have been recognised. Some of them are of excellent grade with a fairly low ash content. The calorific value of many seams approximates 7,000.

Korba Coalfield :– This coalfield, which occurs in the lower Hasdo valley, occupies an approximate area of 200 square miles. A coal seam, 70 feet in thickness, occurs at Korba, but in the present state of our knowledge the coal is of inferior quality. Other seams occur in the area and some of them are of fairly good quality. On the whole this coalfield appears promising and is situated within 24 miles of Bengal Nagpur Railway line. No igneous intrusions have so far been observed. The estimated reserves of coal are 250 million tons of which 25 million tons are of good grade.

Raigarh Coalfield :– This coalfield, having an area of 200 square miles, is situated in the north-west corner of Raigarh State. However, detailed exploration has not been made. Seams of workable thickness occur, but the coal is of inferior quality.

Satpura Basin

These coalfields include those of Kanhan and Pench Valleys and a concise account of the important ones is noted below.

Mohpani Coalfield:– This coalfield occurring near the village of Mohpani was opened up in 1904 and was worked until 1927 by the Great Indian Peninsular Railway Company. Four coal seams are known to

occur and two seams have a thickness of about 20 and 25 feet respectively. The reserves of coal are estimated at 4 million tons.

Betul or Shahpur Coalfields :– A number of coal-bearing areas occur about the Tawa river, but lie mainly undeveloped. Coal seams with a workable thickness occur in the Barakar rocks and the following three coal-bearing areas are known to occur: the Gurgunda, Madanpur and Katasur. The area is disturbed by faulting and several dolerite dykes also occur.

Kanhan Valley Coalfields :– These coalfields occupy a large area and extend from the Kanhan to the Pench Valley. The area has been disturbed by faulting. A coal seam with a thickness of 9 to 15 feet occurs at Damua and one of the outcrops is being worked by the Kanhan colliery. It is a good caking coal. At Ghorawari colliery, which lies farther eastward, a seam 15 feet in thickness, is exploited. This is underlaid by other seams. This seam yields a hard coke. A coal seam, 14 feet in thickness, is worked near Panara. Another seam of caking coal is worked near Dongaria.

Pench Valley Coalfields:– Several seams occur in this area, four of which are workable. The topmost seam, worked so far, has a thickness varying from 5 to 12 feet. The area has been cut up by transverse faulting. Coal has been proved at the following localities: (i) Barkuhi. The upper seam, which is being worked here, is 6 to 7½ feet in thickness. (ii) Bhandaria-Bhutaria. An 8-foot coal seam occurs here. (iii)

Chandameta–Dongar Chikli. Here 6 feet of coal are exploited and the reserves are estimated at 15 million tons. (iv) Eklaira-Newton Chikli area. The Pench Valley coalfields have been exploited since 1905. There are other areas in this region which comprise those of Parasia, Khirsadoh, Rawanwara, Chhinda and Sirgora.

Wardha Valley

In the Wardha Valley coal was first discovered in 1831. In this region the Gondwana rocks occupy an extensive region and the coalfields represent areas where the Barakar coal measures have been exposed. The important coal occurrences of this region are described below.

Bandar Coalfield :– Near Morepur village 4 coal seams have been proved and the total reserves are estimated at 108 million tons. The coalfield is 30 miles from the nearest railway and has therefore not been exploited yet.

Warora Coalfield :– Two coal seams have been proved near Warora, an upper having a thickness of 22 feet in places and a lower seam, about 10 feet in thickness. It is estimated that about 12 million tons of coal with a calorific value of 5,500 occur in this area. A colliery, opened in 1873, was closed in 1906 owing to underground fires, etc.

Rajur or Wun Coalfield :– This coalfield lies in the Yeotmal (Wun) district of Berar. In the neighbourhood of Pisgaon 27 to 13 feet of coal occurs 77 feet

from the surface and at Rajur 18 to 30 feet of coal lie at a depth of 160 feet. The coal is non-caking and not of very good quality. A colliery was developed in 1927. The estimated reserves of coal are 240 million tons.

Ballalpur Coalfield :– Near Sasti two seams, 17 and 14 feet in thickness, occur to a depth of 62 feet. Near Ballalpur several seams of workable thickness are worked by a colliery. The coal is non-caking and not of high grade. In the total area the reserves are estimated at 2,000 million tons.

Hyderabad State

It is to be observed that the coal-bearing Gondwana rocks of this area represent a south-east continuation of the Wardha Valley region and occupy a total area of 4,500 square miles of which 3,800 square miles lie in Hyderabad-Deccan. A brief account of the important coal-bearing areas is given below.

Tandur Coalfield :– An outcrop of coal-bearing rocks extends as far as east of Belampalli railway station. Two workable seams occur which are being worked since 1931.

Singareni Coalfield :– The area of this coalfield, which represents an outlier of Lower Gondwana rocks, is 19 square miles. It occurs near Yellandlapad, about 5 miles north-north-east of Singareni. Four seams occur within a distance of 50 to 250 feet of the surface. The top seam includes 6 feet of good quality coal and a thick bottom Singareni seam has in places a total thickness of about 70 feet.

Cretaceous and Tertiary Coalfields

Coalfields of this group are not important as they furnish below 2 per cent. of India's production, but they may have some regional importance, e.g., in Baluchistan it would represent practically the only available fuel. They occur in Assam, Baluchistan, the West Punjab and Rajputana. Undeveloped coalfields occur in Kashmir and N. W. F. P.

It may be noted that the coalfields of Cretaceous age are only those of the Garo, Khasi and Jaintia hills, while the rest are mainly of Tertiary age.

The outturn of the Tertiary coalfields during the year 1937 is tabulated below :-

	Tons	Percentage of India's Total
Assam		
Khasi and Jaintia hills ..	7,648	
Makum and Lakhimpur ..	218,488	1.00
Naga hills ..	22,427	
Baluchistan		
Khost ..	6,262	
Sor Range, Mach, Kalat ..	11,217	0.07
West Punjab		
Jhelum ..	62,095	
Mianwali ..	98,740	0.67
Shahpur ..	5,797	
Rajputana		
Bikaner ..	32,369	0.13
	465,043	1.87

The reserves of the Tertiary coal are estimated at about 2,300 million tons.

Assam

Garo Hills :- Coal of the Garo hills forms the westernmost deposit in Assam and is now regarded to belong to Eocene age. The basin of Darranggiri, across the Someswari river has a production area of about 20 square miles. The only seam has an average thickness of $5\frac{1}{2}$ feet and the reserves above the main drainage level have been estimated at 76 million tons. The quality of coal is good, but distance from the railway terminus is a serious impediment in the way of exploitation.

Khasi and Jaintia Hills :- In these hills, coal both of Cretaceous and Tertiary age is known to occur. In the Cherrapunji plateau it is known to occur since 1815 and the estimated reserves exceed one millon tons. There are many other small occurrences, but four seams with a thickness of 20 feet and occupying an area of 30 square miles are known to occur. Coal is almost of good quality, some of which is caking.

Upper Assam :- Coal-bearing rocks occur in Upper Assam in the lower ranges forming the southern boundary of the Lakhimpur and Sibsagar districts and the important coalfields comprise those of Nazira, Jaipur and Makum (Namdang-Ledo).

Nazira :- In this coalfield, steeply inclined coal measures extend over a distance of 16 miles. Coal is also known from Dikhu, Tiru and Safrai valleys. In the Tiru-Dikhu area 15 million tons of coal within 600 feet of the outcrop and much of it above ground

water level, has been proved. In the Safrai area another 20 million tons of coal are known to occur. The coal is of hard variety.

Jaipur :—This coalfield lies 20 miles north-east of Nazira and the coal measures extend over a distance of 25 miles. In the southern region the coal seams have a considerable thickness. At least 20 million tons of coal have been proved within a depth of 49 feet, but the quality of coal is said to be inferior and the sulphur-content high.

Makum:—It lies to the east of Jaipur at the southern boundary of the districts of Lakhimpur and Sibsagar; the most important deposits occur at Tirap and Namdang and is also known as the Namdang-Ledo coalfield. One coal seam with thickness varying from 15 to 80 feet and with an average thickness of 50 feet occurs in the area. E. G. Harris estimated in 1900 the reserves at 90 million tons. Its quality is reported to be excellent and is a good gas-producing coal. It is a caking variety, but contains large amount of sulphur. The production since 1909 has generally ranged between 250,000 to 300,000 tons *per annum*. The coal is consumed by the railways, steamers and tea factories.

Bikaner, Rajputana

Lignite deposits of the same age as that of coal in the West Punjab occur at Palana in Bikaner State in Rajputana. The thickness of the seam varies from 4 to 8 feet. It is a friable coal with low ash content and could be used when briquetted. This lignite contains large amount of fossil resin. These deposits have hardly been subiected to any dynamic stresses.

Baluchistan

Coal of early Tertiary age is found in Baluchistan, which since the 15th August, 1947 forms a part of Pakistan's territory. Mining is carried on in the Bolan Pass, in the Sor range, Kalat and Khost in the Sibi district.

There are various exposures above Mach in the Bolan Pass and in the flanks of the Sor range. Many small mines have been worked within 15 to 30 miles of Quetta as also at Mach. The coal is greatly disturbed and the seams are seldom more than 5 feet in thickness. The quality of coal is said to be fair, but for a high sulphur-content.

Anthracite Coal near Jammu

Anthracite coal occurs in the Riasi district of Jammu Province in rocks of early Tertiary age. The seams are 1 to 20 feet in thickness and are widely distributed in 3–4 coalfields over 36 miles of country. According to C. S. Middlemiss[1] the estimated reserves are 100 million tons. The percentage of fixed carbon in these coals ranges from 60-82. It may be noted that these deposits have been involved in the Himalayan movements and have been thus changed into anthracitic coal, much of which is caking.

Coal in the Karewas of Kashmir

Lignite coal occurs in the Older Karewa series within a few feet from the surface. The combustible matter is about 55 per cent. and more than 100 tons

1. Middlemiss, C. S., *Mineral Survey Reports, Jammu and Kashmir State, Coalfields of Riasi, Jammu*, 1980.

of lignite of moderate quality can be easily recovered from one area[1].

Classification of Indian Coal by Composition

According to chemical composition, coalfields of India may be classified as follows :–

1. Lignite deposits of Palana, Bikaner.
2. Lignite deposits of Karewas in Kashmir.

It may be observed that these deposits are of different geological ages. Those of Palana belong to early Tertiary, while those of Karewas belong to a much later age.

3. The numerous coalfields of the Lower Gondwana age yield bituminous to sub-bituminous coal in which the carbon percentage varies from 55-60, while the percentage of volatile compounds and ash is high. Moisture is practically absent and sulphur and phosphorus are present in variable amounts.

4. Coal near Riasi, Jammu is anthracite, representing the best form of coal.

Reserves of Coal

It is to be emphasized that the reserves of coal in India are small and they are approaching exhaustion.

According to L. L. Fermor[2] 4,521 million tons of good quality coal, which is easily accessible, occur. Of

1. Middlemiss, C. S., *Rec. Geol. Surv. Ind.*, Vol. LV, 1924.

2. "India's Coal Resources", *Bull. Indian Industries and Labour*, No. 54,1935, pp. 1-14, also *Rec. Geol. Surv. Ind.*, Vol. LXIX, 1935.

this nearly 1,700 million tons are caking coal, which is used wastefully for steam raising purposes and its life is computed to support Iron and Steel industry of India for a period of 35-50 years. But under a scheme of careful conservation a life of 200 years has been indicated. The remaining 2,827 million tons are non-caking.

In 1932 C. S. Fox estimated the total coal reserves of India to a depth of 1,000 feet at 60,000 million tons of which 20,000 tons are workable; while 5,000 tons are of good quality, while the coal suitable for the manufacture of metallurgical coke is only about one-third. The reserves of Tertiary coal of Upper Assam and the Garo-Khasi hills have been estimated at about 2,000 million tons, while those of Rajputana, the Punjab, N.W.F.P. and Baluchistan represent another 300 million tons. But on account of their high sulphur-content these coals are not suitable for the reduction of iron ores unless the sulphur can be removed by washing. The chief consumers of metallurgical coke are Tata Iron and Steel Co. Ltd. and India Iron and Steel Co. Ltd. and about 2 million tons of coke are manufactured annually. This will reveal that the life of our good quality caking coals, required for metallurgical purposes is very limited.

Utilisation

It is noteworthy that the exports of coal are insignificant and nearly 98 per cent. of the total output is consumed in India. The railways, the mines, ships, the jute and cotton mills, iron and steel companies, and industrial works are the chief consumers of Indian coal. About one-ninth of the total output is used

in the manufacture of metallurgical coke for smelting iron, the remainder is burnt raw with a complete loss of by-products under boilers for steam raising and domestic purposes. The railways consume about one-third of the output and bunker coal is supplied to the coaling stations of the Indian Ocean along with those of the West Coast.

It must be stated that some of the above utilisation is definitely not efficient and rational. On the other hand some of the methods of utilisation are undoubtedly wasteful. For example, the railways consume a considerable proportion of high grade coal where other grades may be equally suitable. Dr. L. L. Fermor has already referred to the wasteful utilisation of Giridih caking coals. It is suggested that pulverised coal could be used for the purpose. This will no doubt prolong the longevity of caking and chemical grade coals which should not be used for steam raising purposes. Caking coals should be exclusively used in metallurgical operations, while inferior grade coals should be subjected to gasification. It has also been shown that considerable quantities of feebly caking coal can be mixed with good caking coal to produce sound metallurgical coke. Malpractices in utilisation leading to wastage of coal should definitely be discouraged and stopped as early and as far as possible.

Trade in Coal

In passing a reference may be made to India's trade in coal. It must be understood at the outset that India's trade in coal comprises the coastal trade and

the export trade. It is noteworthy that her coastal trade is fairly substantial, but her actual export trade is somewhat small. Regarding the former, the size of the country and her lengthy sea-board have to be kept in view. Moreover, as discussed in the foregoing, the major coalfields lie within a short distance of Calcutta. It, therfore, proves more economical to send coal to the various ports of India and in some cases to the adjoining hinterland by sea rather than by land as sea transport is much cheaper than road or rail transport. Many industrial concerns in the country, e.g., the textile mills of Bombay, the various Kathiawar State railways, cement factories on the West Coast, etc. receive their coal supplies from Calcutta. This coastal trade between the various Indian ports comprises one million tons *per annum*.

Burma has been separated from India and coal supplied to Burma now represents true exports. Burma's annual imports of coal exceed half a million tons which is mainly supplied by India. In Burma the important buyers of Indian coal are the Burma Railways, the Irrawaddy Flotilla Co., and the steamers especially plying between Burma and India.

The important export markets of India comprise Ceylon, the Straits Settlements (Singapore, Penang, Port Swettenham, etc.), Manila, the Chinese ports and Aden with other ports west of India. In this connection an embargo is placed sometimes on the exports of coal in the interest of Indian industry owing to the serious shortage of railway wagons. To retrieve such a posi-

tion the Government of India appointed the Indian Coal Committee in 1924, which recommended the institution of the Coal Grading Board, concessions in railway freight and port charges. This assistance proved helpful to the industry to withstand competition with foreign coal at ports in India and Burma. Further assistance in 1936 by way of a special rebate in railway freight and port terminal charges on coal for export enabled India to recapture Ceylonese market of 150,000 tons *per annum*. It also helped to improve her export position in the Straits, Manila, etc. The export figures for the year 1935–1938 are given below:–

1935	200,000	tons.
1936	200,000	,,
1937	475,000	,,
1938	775,000	,,

The enhanced exports in 1938 are to be attributed to the Sino-Japanese War which naturally affected the Chinese industry, but the export figures of nearly 500,000 tons in 1937 are without any exports to China.

The export figures for 1937 and 1938 to the various markets are given below :–

Countries	1937	1938
Ceylon	3,69,280	2,72,514
Straits Settlements	66,777	30,747
Far East	7,528	4,61,690
Aden, etc.	16,766	3,362

The most important ports, which receive shipments of Indian coal comprise Colombo, Rangoon, Singapore, Shanghai and Aden.

In view of her limited reserves, it is not known how far India can really develop an export trade in coal which is a basic industry and is essential in the stability of other industries. Transport provides another difficulty which hinders the movement of coal even within India. There is no doubt that there is a sustained demand for Indian coal in Pakistan, Ceylon, Burma, China, Japan and Australia. For this, quick and efficient transportation of good quality coal are really essential.

Conservation of Coal

Conservation of coal involves two stages. The first involves the maximum extraction. At present coal in India is generally mined by Board and Pillar method. In order to effect the maximum extraction, the method of sand stowing has been introduced. The spaces rendered empty by the mining of coal, are gradually filled with sand. In this way collapses in the mines with danger to life are minimised and by judicious sand stowing, more than 90 per cent. of coal can be extracted.

The second stage comprises judicious utilisation. At present our caking coal, which could be conserved for our iron and steel industry, as noted above, is wastefully used for steam raising and other domestic purposes. This coal should be definitely conserved as far as possible as India possesses very large reserves of iron ore

which could last for centuries, while our suitable coal reserves are very limited indeed. Hodgrove has aptly stated "coal is an immensely valuable chemical substance which only a primitive industrial civilisation would treat as fuel." Coal, when treated suitably, can yield a host of very useful products. Shalimar Coal Tar Products have made a beginning in this direction.

It would, therefore, appear from the above that it is all the more imperative that India begins to develop its great water power resources, which are exploited at present only to an extremely poor extent. This subject has been dealt with in the chapters which follow. No doubt maximum use should be made of cheap water power and coal should be conserved as far as possible. The author would propose the appointment of a Fuel Commission which would include experts on all types of fuels including coal, petroleum, water power, etc. This Commission would take stock of all kinds of fuels and recommend their judicious utilisation. At present very great resources of water power remain unexploited and minerals, like coal and petroleum, which are vanishing assets, are being wastefully utilised. It would thus appear that conservation of coal is an immediate problem confronting India.

Labour

The coal mining industry employs on an average about 1,75,000 workers *per annum*. The number of persons employed during the year 1937, with the highest output in the whole history of coal mining in India, was 1,94,705, while during the previous year 1,81,687 persons found employment.

Petroleum

Petroleum or mineral oil is found in rocks and associated with it some natural gas generally occurs. Petroleum represents the second important mineral fuel and has a complex composition, being a mixture of hydrocarbons, mainly liquid with some gaseous and solid ones. Its general composition is as follows :—

Carbon	...	...	...	80-17 per cent.
Hydrogen	...	...	...	12-14.1 „ „
Oxygen	...	...	...	6.9 „ „

Assam

In India oil occurs in Assam. In fact a belt stretches from the north-east of Assam across the eastern borders of the Brahmaputra and Surma valleys to the islands of Ramri and Cheduba, over a distance of 800 miles. This belt is parallel to that of the Central belt of Burma, which is separated by the Arakan Yomas. The oil-bearing rocks are of Eocene, Oligocene and Miocene ages and compressed anticlinal folds represent the structure. The belt has been explored fully and the oilfields of commercial value are as follows :-

(a) Digboi in the Lakhimpur District, Upper Assam.

(b) Badarpur in the Surma Valley.

(c) Masimpur and Patharia in the Surma Valley.

(d) In small quantities oil occurs in the Makum-Namdang area.

Digboi Oilfield :—It lies about 7 miles north of Margherita. Drilling was begun in 1888 and produc-

tion commenced in 1892. This field, which is worked by the Assam Oil Company, has now been proved over a length of $2\frac{1}{2}$ miles comprising Digboi, Bappapung and Hansapung areas. The structure of the oilfield is an asymmetric anticline with a steep fault in the northern flank. In this region oil and coal occur associated.

Badarpur, Cachar District :—As oil seepages occur here, drilling was undertaken. The oilfield is a small dome, with a steep faulted eastern flank. It is a mile in length and a quarter mile in breadth. Production commenced in 1917 and in 1920 it reached over 8 million gallons, but it rapidly declined. In 1932 it was a little over 800,000 gallons. The oil is of poor quality with large quantities of associated water. The field was abandoned in 1933.

West Punjab

There is another oil belt in the north-west comprising parts of the West Punjab, N.W.F.P., Baluchistan and Sind in Pakistan. This belt continues on to Iran and Iraq.

In the West Punjab oil occurrences are found in the Attock, Mianwali, Rawalpindi and Shahpur districts. In the North-West Frontier Province such occurrences are found in the Kohat district and the Shirani hills. Similar localities are known inBaluchistan.

The oil-bearing rocks were deposited in a gulf in the Tertiary period, but they have undergone considerable erosion and have been dislocated by earth-move-

ments and consequently much of the oil has been dissipated. Consequently there may be no big reservoirs capable of yielding large production.

Khaur :—This oilfield lies on the Potwar plateau and is 43 miles from Rawalpindi. It is the only producing field in the Punjab and has a length of 7 miles with a maximum width of $1\frac{1}{3}$ miles. It is thus a long and very slightly asymmetrical open anticlinal fold.

Oil occurs in sandstones of Murree age (Lower Miocene), but it appears to have migrated from the underlying limestones of Chharat series of Eocene age. Deep drilling has proved the occurrence of oil and gas in the Eocene limestones at Khaur and in the adjacent Dhulian dome. Oil sands occur from 4,000-4,800 feet which represents the oil-bearing zone.

Drilling commenced in 1915, but the output remained small. The company completed its refinery at Rawalpindi in 1922 and during that year $7\frac{1}{2}$ million gallons of petroleum were produced. Production has varied between 6 and 19 million gallons in 1929 which was a record output, but in the following years it declined to $7\frac{2}{3}$ million gallons.

Dhulian :—This oilfield forms a dome which occurs 8 miles W.S.W. of Khaur. It has the same length as Khaur, but it is slightly broader. Recently successful boring to a depth of 7,100 feet in this field has increased production.

Joya Mair:– D. N. Wadia[1] has mapped this dome near

1. *Rec. Geol. Surv. Ind.*, vol. LXI, 1929, pp. 358-362.

Chakwal in the Jhelum district of the West Punjab. The structure, which is suitable for the accumulation of oil, comprises an area exceeding 10 square miles. It lies within an area of active petroleum prospecting. This dome occurs on a level much dissected plateau. The same author was of the opinion that the structure of the Joya Mair dome is favourable for the accumulation of oil underground on a promising scale which has been proved by subsequent drilling. Another favourable factor responsible for the bringing of the oil-bearing Nummulitic limestones (Chharat Stage) nearer the apex of the fold has been the absence either entirely or mainly of the Murree series.

India imports large quantities of kerosene and petrol, the total amount being many times greater than her own production. However, Assam and the West Punjab export 20,000 tons of paraffin wax *per annum.*

Power Alcohol

Power alcohol industry is of great national importance to every country of the world, but more particularly to India, where the resources of petroleum are practically negligible. Power alcohol can be manufactured cheaply from molasses and potatoes. India produces large quantities of molasses as a by-product of her sugar industry so much so that there is a perpetual glut of molasses in the sugar factories. In the United Provinces and Bihar, the two important sugar-producing provinces, there are more than 150 large vacuum pan factories which produce enormous quantities of

molasses and the surplus could be put to the profitable use for the manufacture of power alcohol.

It is very remarkable that great initiative was taken by the States of Mysore and Hyderabad in the manufacture of power alcohol. Both these states had large interests in the sugar factories located in their territories and it was undoubtedly a profitable proposition for the disposal of the surplus molasses. The first distillery for the manufacture of power alcohol was established at Mandya in Mysore State followed about a couple of years later by a much larger one at Bodhan in Hyderabad-Deccan.

There was some antagonism to the establishment of this manufacture in the provinces of India, but in 1938, when the Congress Ministries came into power, a Joint Power Alcohol and Molasses Inquiry Committee was established at Kanpur (Cawnpore) by the Governments of the United Provinces and Bihar. The Committee made unanimous recommendation for immediate setting up of the industry and the legislatures of the United Provinces passed the Power Alcohol Act and according to it 25 per cent. of power alcohol was to be used in admixture with petrol. When the Second World War looked imminent, there was a change in the attitude of those who opposed the establishment of the industry.

There was only one distillery for power alcohol at Meerut in the whole of India, excepting the Indian States and the distribution of petrol-power alcohol mixture to the public was confined to the two districts

of Meerut and Agra only. It is noteworthy that the industry established itself under the most unfavourable conditions of the critical periods of the War, when there was an acute shortage of the building materials for construction and the manufacture of machinery. But by 1946 nine complete plants for the manufacture of power alcohol were constructed which commenced manufacturing. It is noteworthy that these plants, manufactured locally, have proved as effective as any imported one. The United Provinces produce more than 90 per cent. of power alcohol manufactured in the country. The annual production of molasses is 6,000,000 maunds sufficient to manufacture 10,000,000 gallons of power alcohol. The installed capacity for the manufacture of power alcohol is about 6,000,000 gallons, while the actual production in 1947-48 was 2,700,000 gallons consuming somewhat more than 1,250,000 maunds of molasses. This short production is attributed to non-supply of requisite quantities of molasses and to some extent to coal to the distilleries. This short supply really means the shortage of transport. A closer association between the sugar factories and power alcohol distilleries is likely to prove of lasting benefit to both the industries.

It may be noted that the Transport Department of Travancore has been utilising petrol mixed with power alcohol for running its motor buses.

It may be observed in passing that with the impending prohibition to be introduced in the United Provinces, the distilleries are devoting their increased attention to the manufacture of alcohol for industrial

purposes. It also includes the manufacture of chloroform, acetic acid, etc. and the extraction of drugs and alkaloids. It would be desirable to manufacture by-products of molasses such as dry ice, potash, etc. The establishment of a food yeast factory is also well worth consideration.

In conclusion it may be stated that the power alcohol industry is undoubtedly of great national importance both from the point of view of using the molasses which would otherwise be wasted and of establishing in the country an industry which would be of importance in times of emergency. The manufacture of power alcohol would also reduce the price of sugar and reduce our dependence on petrol.

Synthetic Petrol

In passing it may be noted that the Government of India are already engaged in investigating the possibilities of the manufacture of synthetic petrol from coal. The experts visited India in July, 1948 to report on the feasibility of manufacture of one million tons of motor spirit and diesal oil by extraction from coal. The process implies the gasification of coal and subsequent synthesis of some of the products.

It is estimated that every ton of petrol manufactured would require seven tons of coal, which signifies that seven million tons of coal per year representing one-fourth of our current annual production, would be the annual requirement for the process. Incidentally this may provide opportunity for the profitable utilisation of non-caking coal of which a fairly large supply is available in India.

CHAPTER XVII

HYDROELECTRIC RESOURCES

A Plea for Development of Water Power

Nearly 80 per cent. of the working population of India is directly or indirectly dependent upon agriculture. There is no doubt that India's agriculture has failed very miserably as the country is practically engaged in producing food alone, but it does not produce even enough food to feed its people. The poverty of India has been attributed by several eminent authorities to its being dependent upon agriculture. Such a state of affairs has been aptly described as a great misfortune. Furthermore, the population of the country is progressively increasing, while on the other hand the amount of land is limited whose fertility is diminishing every year or, in other words, there is a progressive increase in the deterioration of the soil. This tremendous pressure on land by reckless deforestation has also brought the menace of soil erosion, floods, etc. The same fact is also responsible for small uneconomical holdings which bring low incomes. This evidently results in a constant lowering of the standard of living bringing in its wake poverty, more poverty and chronic poverty. It has also been suggested that a complete solution of the problem does not lie in the improvement of India's agriculture by way of propaganda for more irrigation, better manuring, proper rotations, improved seeds, improved implements and better breed of animals. Of course as much cultural waste land as

possible should be brought under the plough in this drive for 'Grow more food'. It has been observed that progressive countries reduce their agricultural population, while the actual production from agriculture is increased. The United States of America provides a very good example. About a century ago the conditions in the U. S. A. were almost comparable to those of India employing about 70 per cent. of its population. But as a result of industrialisation, it was possible to reduce the population dependent upon agriculture to 22 per cent., but at the same time her agricultural yields were nearly doubled. However, the real solution of the problem lies in the industrialisation of the resources of the country. Although this solution has been suggested before, but yet there has been no concerted drive to actually bring about industrialisation.

In case India is to be industrialised successfully the development of cheap and abundant power is very essential. It has been stated in the foregoing that the reserves of coal required for metallurgical and other purposes are limited and in the interest of the country should be conserved, while there are practically little reserves of petroleum. We have, therefore, to depend mainly on water power which as cheap motive power is the first *sine qua non* for industrial development. It is gratifying to observe that the country, particularly the noble and the mighty Himalayas, abounds in rich potential resources of hydroelectricity and India can be one of the leading water power producing countries in the world. In fact the Himalayas constitute the greatest reservoir of water power in the

world and it is left to the genius of the people of the country to exploit it properly for the benefit of the teeming millions of India. It is surprising that only about 6 per cent. of the surface and underground water resources of the country are exploited. Furthermore, only about two per cent. of these water power resources have been developed so far. India's potential resources of water power have been estimated at forty million K. W. or even more, but the present installed capacity of water power is below half a million kilowatts of water power and one million kilowatts of thermal power. Compared to this, the following table shows the percentage development of water power of some of the advanced countries of the world :—

Switzerland	...	67	per	cent.
Germany	...	59	,,	,,
Norway	...	53	,,	,,
France	...	42	,,	,,
Canada	...	34	,,	,,
Soviet Russia	...	34	,,	,,
Sweden	...	27	,,	,,
U. S. A.	...	24	,,	,,
India	...	2.5	,,	,,

Our present projects for the development of hydroelectric power will raise it to 3 million K. W., but this will mean only 7 or 8 per cent. of our potential water power resources. The annual *per capita* consumption of power (both water and thermal combined) of different countries is compared below :—

Canada	...	3,580	Kilowatt	Hours
Norway	...	3,579	,,	,,

U. S. A.	...	1,775	Kilowatt Hours
Sweden	...	1,743	" "
Switzerland	...	1,717	" "
United Kingdom	...	855	" "
India	...	12	" "

It is really difficult to comprehend why these abundant resources of power have remained unexploited and India's resources of coal are being wastefully exhausted. Within recent years some of the new projects like those of the Damodar Valley, the Kosi river, the Hirakund project on the Mahanadi, the Rihand Dam, etc. have been under consideration. It is only to be hoped that not only these schemes will be completed without further delay, but a detailed survey or resurvey should be made of the hydrographic resources of the country, devising multipurpose schemes for flood control, perennial irrigation, development of hydroelectricity, navigation and no doubt the additional development of fisheries in the great storage reservoirs. In this way not only the hydroelectric resources, so essential for industrialisation, will be developed, but also much needed irrigation could be augmented to meet the food shortage in the country. It may be noted in passing that the completion of the important river valley projects in hand would irrigate another 6 million acres of land as follows: Damodar Valley scheme in Bihar and West Bengal: 980,000 acres, the Bhakra Dam in the East Punjab: over 3 million acres, the Tungabhadra Dam in Madras and Hyderabad: nearly 1,800,000 acres and the Hirakund Dam in Orissa: over a million acres. It has been aptly stated thatafr a ction of our water resources, if properly

utilised, will create extra wealth to the order of between Rs. 3,000,000 and Rs. 4,000,000,000 *per annum.*

Geographical Factors:—Important geographical factors, which determine the development of hydroelectric power, are topography, rainfall and run-off from a catchment area. Unfortunately India's rainfall in most parts is seasonal, i. e., a large part of it falls from June to September or October. This is particularly true of Western India. Only the South-east Peninsula receives some rain from the N. E. Monsoon during September-December. The Punjab and the United Provinces have some winter rainfall. But on the whole over a great portion of India there is the monsoon season followed by a long dry season. It may be noted, however, that Assam, East Bengal and the West Coast receive abundant rainfall and the rainy season is also somewhat comparatively longer. It may also be noted that these regions are favourably placed from the configuration point of view providing suitable sites for storage purposes and the variability of rainfall in these regions is not serious. It must be concluded, therefore, that in those regions, which have a low seasonal rainfall, water will have to be accumulated in storage reservoirs for a regulated flow to be used for generating hydroelectricity.

The rivers of Northern India are fed, however, both by the monsoons and the snows of the Himalayas and thus have a perennial flow. But even here storage dams will have to be built to save the colossal waste of the monsoon water which flows unchecked to the sea and causes devastating floods on the way.

The havoc wrought by the unprecedented floods of 1948 in the U. P., Bihar and Bengal is still fresh in our memory. These circumstances, therefore, provide

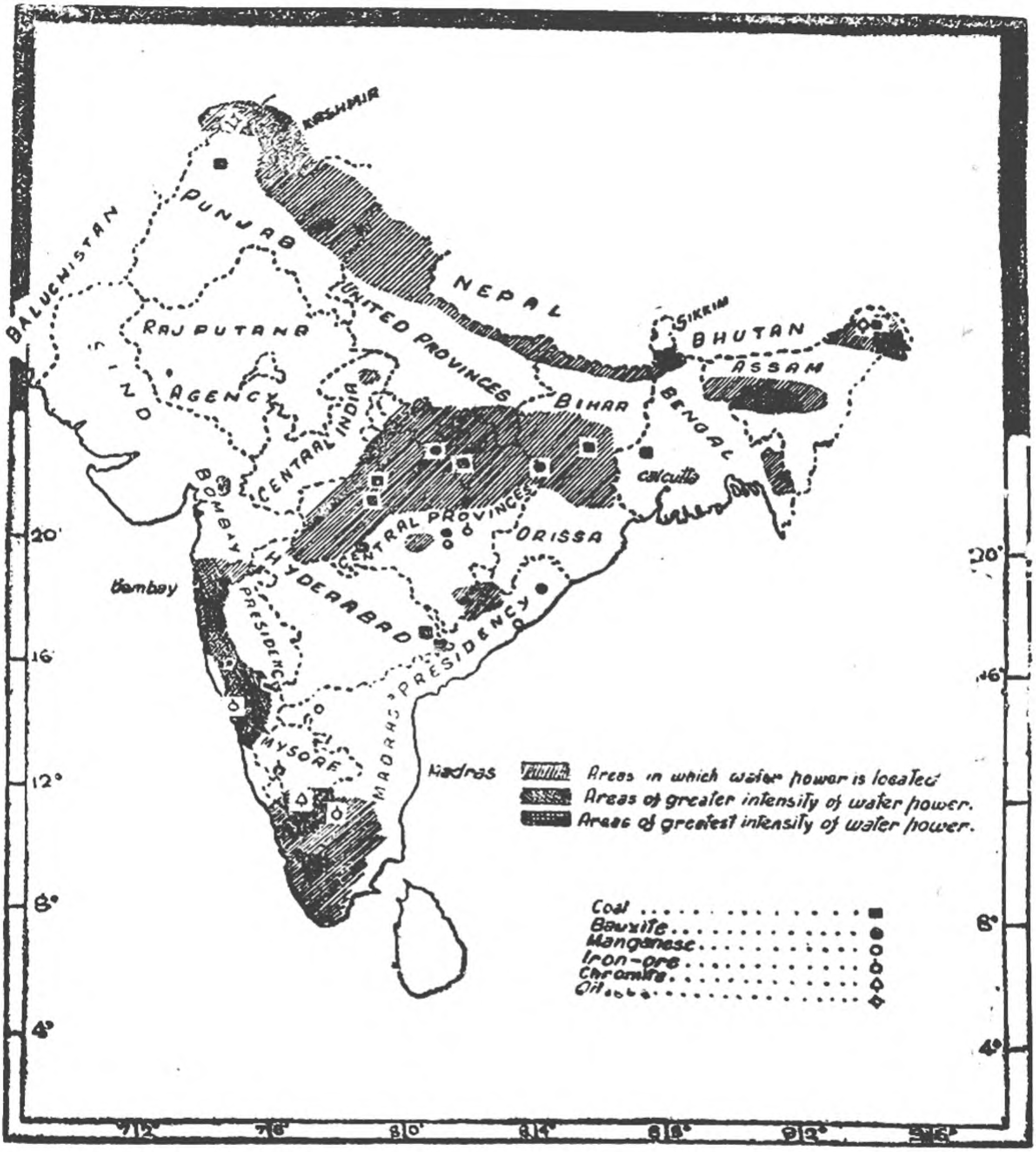


Fig. 27—Showing the different areas with varying intensities of water power resources. The occurrence of coal, oil and some important minerals is also shown.

opportunity for multipurpose schemes. Fig. 27 shows the different areas with varying intensities of water power resources.

Multipurpose Projects

It is proposed to include a brief account of the important new projects which have been investigated and proposed for multipurpose developmental schemes. It is intended to impound water in huge reservoirs by building dams across some of the rivers at suitable sites. It will be seen that the water, which was allowed to flow uselessly into the sea and caused huge devastation to crops and property on its way, could be stored and made to provide the much needed irrigation, cheap water transport and the hydroelectric energy so urgently required for industrial development. In some cases the river by drifting, e. g., the Kosi has devastated large areas of agricultural lands by depositing infertile sands over them. This will not only be checked by trapping the harmful sands in the reservoir, but the lands thus lost along with the waterlogged areas by improving drainage will be reclaimed and restored to agriculture. Thus the pestilence of malaria, which takes such a toll of human life and energy in these regions, will be effectively checked. In these large reservoirs of water there will be possibilities offered for the development of extensive fisheries, and field for sport and recreation. It is, therefore, necessary to study these schemes carefully to find out what resources can be developed immediately and also what is the trend of modern development in harnessing these waters for the benefit of mankind in the domain of agriculture, industry, transport, fisheries, sport and recreation, etc. The schemes, which would yield a high rate of return in the amount of consumable water

power produced, will receive priority over others. Planning on a multipurpose basis really means planning the integrated economic and social development of a river basin. The modern trend of such development is to entrust such projects to autonomous administrative bodies like the Tennessee Valley Authority in U. S. A. or the Damodar Valley Corporation in India. There is no doubt that these multipurpose river valley projects are of fundamental importance. Their development is indeed imperative to raise the standard of living in the country.

Snow Surveys

As a number of multipurpose schemes are under investigation, it has been deemed feasible to undertake snow surveys in the Himalayas as the big rivers, descending particularly from the Great Himalayas are fed by the melting of snow and ice during the dry season, thus making their flow perennial. This makes an important contribution to the economy of the Himalayan rivers. Thus in any important scheme in the Himalayas, e. g., the Tista or the Kosi, it is essential to determine the run-off provided by snow and glaciers. The snows have also a great influence on the onset and the amount of rainfall available from the monsoons. By making snow surveys it is possible to forecast the amount of water available during the dry season.

The Government of India recently invited Dr. J. E. Church, President of the International Commission of Snow and Glaciers to lay out a Snow Survey System

in the Himalayas. In the headwaters of the Tista and the Kosi four parties had been organised in Nepal and Sikkim in the months of April and May, 1947 and a series of snow courses, ranging in height from 11,000 to 15,000 feet, have been laid. A plan has been devised for the establishment of a chain of substations in the Himalayas with headquarters in Simla to collect the necessary data helpful in the construction of dams for the chief Himalayan rivers. The survey will be continuously carried out during the next 10 years. This period is necessary to enable the run-off from the melting snow to be forecast with certainty before the multipurpose dams could be built in the Kosi and Tista Valleys in the Eastern Himalayas. These snow surveys are expected to become a permanent feature in the scientific exploration and development of India.

It has been found that rivers with catchment basins below 10,000 feet above sea level are mainly dependent on rains.

The snow-line, marking the lowest limit of perpetual snow in the Himalayas, has been described on page 22 of Part I of this work.

Hydroelectric Schemes

In the sequel are described the various hydroelectric schemes which have been developed or are in course of investigation (See Fig. 28).

Hydroelectric Works in Jammu and Kashmir

There are three hydroelectric works in Jammu and Kashmir State. The first was started more than 40

years ago and is located near Buniyar on the Jhelum, about 14 miles from Baramula and 50 miles from Srinagar. The power house is at Mohora, about $6\frac{1}{2}$ miles from the power installation on the Jhelum. The

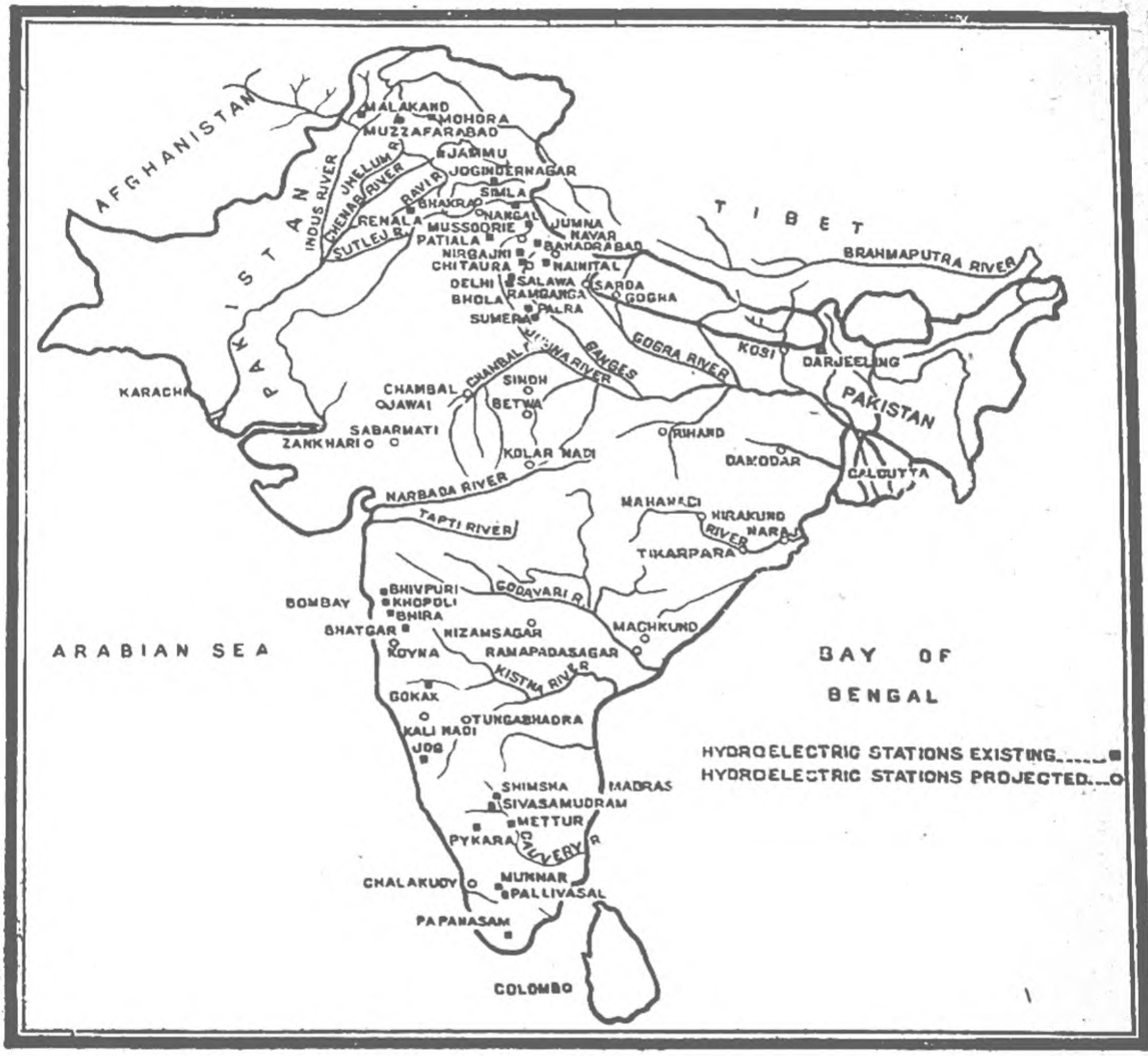


Fig. 28—Showing the existing and projected hydroelectric works in India.

installed capacity is 20,000 H. P. and the whole of Srinagar, the capital of Kashmir, is electrically lighted and the State Silk Factory is one of the principal consumers of hydroelectricity.

The power at Baramula was originally utilised for three floating dredgers and two floating derricks for dredging the river and draining the swampy country-side to make it suitable for agriculture.

The other two works are located at Jammu and Muzaffarabad. The former utilises the water and a fall in the Sri Ranbir Canal which flows by Jammu. The power house at Jammu has 5 generating sets. Of these, four are driven by water turbines which generate 1,226 K.W. of water power and the fifth one of 265 K.W. is driven by a Diesel oil engine. This scheme has been responsible for supplying electricity to this town. The Muzaffarabad scheme utilises waters of a tributary of the Kishenganga and serves the towns of Muzaffarabad and Domel.

A hydroelectric project to harness the waters of the Sind river to generate 9,000 K.W. of power near Ganderbal is being surveyed. Smaller schemes to supply power to Pahalgam, Anantnag and Udhampur are under investigation. A large scheme to harness the waters of the Chenab to develop power is also under consideration.

N. W. F. P.

The irrigation supplied by the waters of the Swat river by driving the Benton tunnel under the Malakand Pass and the construction of the Upper Swat Canal has already been referred to on p. 19 of this work. An advantage of a natural fall of some 250 feet to generate hydroelectric power was taken by driving a new tunnel called Burkit Tunnel, 12 feet in diameter and with an

available discharge of 800 cusecs. The generating plant comprises three reaction turbine sets each generating 3,200 K. W. The power is transmitted to Mardan and thence to Peshawar Cantonment. It is also intended to supply power to important towns and rural areas. The scheme is operating since 1938.

It is designed to instal three additional generating sets, thereby increasing the total power to 20,000 K. W. The transmission lines are being extended to Wah and Haripur and it is proposed to extend them further to Kohat.

WEST PUNJAB

Rasul Hydroelectric Scheme

This scheme has been designed to generate 22,000 K. W. at Rasul headworks from water to be dropped from the Upper Jhelum Canal to the Lower Jhelum Canal. The scheme is estimated to cost 8.18 crores of rupees and is intended to provide tube well irrigation to some of the districts. The power is proposed to be utilised as follows :—

(a) Operation of 1,800 tube wells to be installed on the channels of the Northern Canals. (b) Supply of power for industrial and lighting purposes to towns in the districts of Shahpur, Jhelum, Gujrat, Sialkot, Gujranwala, Sheikhupura, Lyallpur and Jhang. (c) Supply of power to the extent of 5,000 K. W. to the Mandi Power Scheme during the low water season of the Uhl.

The construction of the scheme was expected to be completed by the middle of 1949.

Mangala Hydroelectric Scheme

This project is intended to generate 10,000 K. W. of water power at Mangala near the headworks on the Upper Jhelum Canal from a head of 30 feet and a minimum flow of about 5,000 cusecs. The power station is proposed to be linked with Grid substation at Jhelum belonging to the Rasul Hydel Scheme.

Additional power at Jogindarnagar, as an extension of the Mandi Scheme, described below, is also proposed to be generated by the installation of a pipe line and two 12,000 K. W. generating sets. In cold weather periods, when there will be shortage of water in the Uhl river power will be supplied from Mangala, but when that generating plant will be closed during summer, it will be supplied by these new sets at Jogindarnagar, which at that time of the year has ample water to operate these new machines.

Thus these two new schemes are intended to supplement each other during low water seasons and will ensure a constant supply of additional hydroelectric power throughout the year. The estimated cost of the scheme is about one crore of rupees and it is likely to be completed in 1951.

Mandi Scheme

Mandi Hydroelectric works have been established in Mandi State, which represent the first major scheme developed in the Himalayas for a general provincial

supply. This is a very ambitious scheme which will be developed in three stages, the first of which has been completed already. The waters of the Uhl river and its tributary, the Lamba Dag, have been harnessed to generate power. The catchment of these waters occupies 250 square miles at altitudes varying from about 6,000 to 16,000 feet at the source of the Uhl. The combined waters of the Uhl and the Lamba Dag are taken by a weir to a filtration chamber for eliminating the gravel and sand transported by them. To carry these waters to the power house at Shannon near Jogindarnagar situated to the west of the Uhl, at an altitude of 4,100 feet above sea level, a tunnel, about three miles in length, had to be cut in the hillside. It may be noted that this is one of the largest tunnels in India. The difference of level between the entrance and the exit in the tunnel is only 125 feet in order not to allow the velocity of the water through the tunnel to be very great. The normal discharge in the tunnel is 600 cusecs, which can be raised to 800 cusecs in case of necessity. The tunnel, at about 1,100 feet from the exit, bifurcates into two steel pipes, each having a diameter of 6 feet. Both these steel pipes bifurcate again into two smaller steel pipes, each four feet seven inches in diameter. Two pipes are operating at present, while the remaining two are intended to function at a time when it is proposed to generate additional power.

In brief this scheme is a great feat of engineering and below the tunnel there is a head of 1,800 feet to the power house at Shannon. The initial installed capacity is 48,000 K. W. consisting of four generating sets of 12,000 K. W. each, one of them being a standby. It

may be noted that in the second stage, which envisages a construction of a dam, 250 feet in height in the Uhl gorge near the headworks, the storage of water will double the flow in the tunnel, which could thus double the present installed capacity.

In the third stage of development, the water flowing out of the generating station could be taken along an open duct, three to four miles in length, to Kun and dropped through another fall of 1,200 feet to a second generating station, where another 48,000 K. W. could be developed. After allowing for standby plants, the total power generated will be 120,000 K. W. The water could be used a third time, if required, as there is another fall of 750 feet below the second generating station.

The total capital expended by the end of 1938 was 7.34 crores of rupees and it was expected that it would pay a dividend of 6 per cent. by 1945-46. The power generated at Jogindarnagar is transmitted to sub-stations at Kangra, Pathankot, Dhariwal, Amritsar and Lahore. It may be noted that the distance from Jogindarnagar to Lahore is 173 miles, while that from Jogindarnagar to Lyallpur is 262 miles, as compared to the economic limit of 250 miles. The power is supplied to the workshops of the N. W. Ry. at Moghulpura near Lahore, the textile mill at Lyallpur and many other industrial concerns. It is noteworthy that the scheme serves a population of 1½ millions and an area of 46,000 square miles.

With the help of this power the question of introducing tube well irrigation scheme, as in the United

Provinces, is under investigation as also the draining of 50,000 acres of waterlogged land. It was proposed to give a bulk supply to the Delhi Province, but this has not materialised yet.

This scheme has come in for a considerable acrid criticism. The cost of generating power has been excessively high and it is cited as an example of mis-management and world record for dearness.

EAST PUNJAB

Bhakra Dam Project

The irrigation aspect of this project has already been dealt with in Chapter II of this book. The dam, which will be built across a gorge of the Sutlej river, will be 480 feet in height. The reservoir, thus impounded, will have a capacity of 3.5 million acre feet and will provide a mean discharge of 6,300 cusecs for 270 days, representing the dry season of the year. The irrigation canals will comprise 200 miles of lined canals with a network of distributaries and will benefit an area of 4.5 million acres. The scheme is expected to cost 70 crores of rupees. It is to be noted here that it will generate 1,88,000 K. W. of energy. The work on the Bhakra Dam has already begun. A railway line to the dam site has been laid and the construction of the diversion tunnels has commenced. Attempts are being made to procure the requisite plant and machinery. The scheme is expected to be completed by about 1956.

Nangal Power Project

This project consists of a weir across the Sutlej at Nangal, 8 miles below the site of the Bhakra Dam. A lined canal from Nangal to Rupar having a capacity of 10,000 cusecs will be taken off for 2 power houses located at 12 and 18 miles below the weir. A fall of about 98 feet will operate each power house and will have an installed capacity of 48,000 K. W. in the pre-Bhakra stage. The capacity of each power house will be increased by 24,000 K.W. in the post-Bhakra stage. The firm power produced in the pre-Bhakra and post-Bhakra stages will be 80,000 K.W. and 140,000 K.W. respectively.

The cost of the project in the pre-Bhakra stage including transmission and distribution will be Rs. 22 crores and it is expected to be completed by 1951.

The project provides for double transmission lines from Nangal to Ambala and a single circuit onward to Delhi via Panipat. Transmission lines will also connect Nangal with Jullundur and power will be further supplied to Ferozepur, Fazilka and Pakpattan. There will be branch lines connecting with Karnal, Abdullahpur, Patiala, Nabha, Bilaspur, Naraingarh in Sirmoor State, Khanna, Jograon, Moga, Kot-Kapoora, Bhatinda, and Abohar towns.

This project will provide power for the construction of Bhakra Dam, for the industrial and economic devlopment of the area and for tube well pumping to supplement the irrigation of the Sutlej Valley, Sirhind and Western Jumna Canals.

Patiala State

This project comprises the construction of a dam across the Ashni *nadi*, about 4 miles from Kandaghat near Simla. It will impound 163,000 acre-feet of water and will generate about 16,000 K.W. of firm power having a load factor of 70 per cent. The Patiala Government have sanctioned the project which will cost Rs. 5 crores and will take four years in completion.

THE UNITED PROVINCES

Upper Ganges Canal Hydroelectric Grid

The Upper Ganges Canal, between Hardwar and Aligarh, has 13 falls each averaging 10 feet. Of these ten are suitable for the development of hydroelectric power of which 7 have been actually developed. Two falls have been combined into one of about 20 feet for the main power house at Bahadurabad station which was completed in 1931. The output of this station is 4,400 K. W., which could be increased by another 1,000 K. W. At Bhola the minimum water available is 1,700 cusecs with a head of 12 to 14 feet and the total generating capacity is 2,700 K. W. At Palra the head is only 8 to 10 feet. As noted above, seven of these falls have been harnessed and power houses have been constructed at Bahadurabad, Bhola, Palra, Bulandshahr, Sumera, Chitaura and Salawa to generate 15,000 K. W., the total installed capacity being 18,900 K. W. Two standby steam power stations, one of 9,000 K. W. at Chandausi and the other of 6,000 K. W. at Moradnagar, have been built.

Pathri Hydroelectric Scheme:— This scheme with a capacity of 19,500 K. W. will operate on a 32 feet

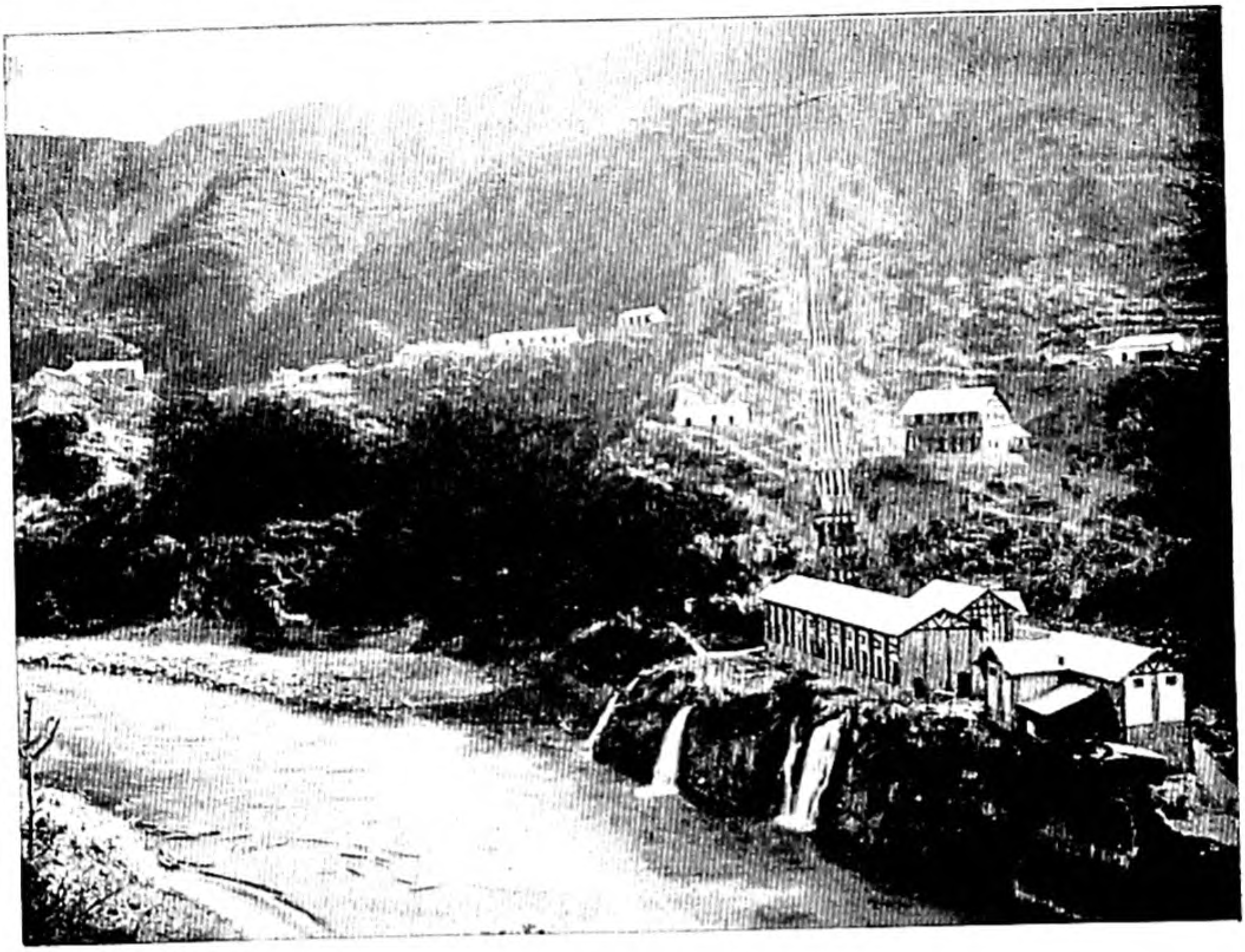


Fig. 1—Simla Power House.

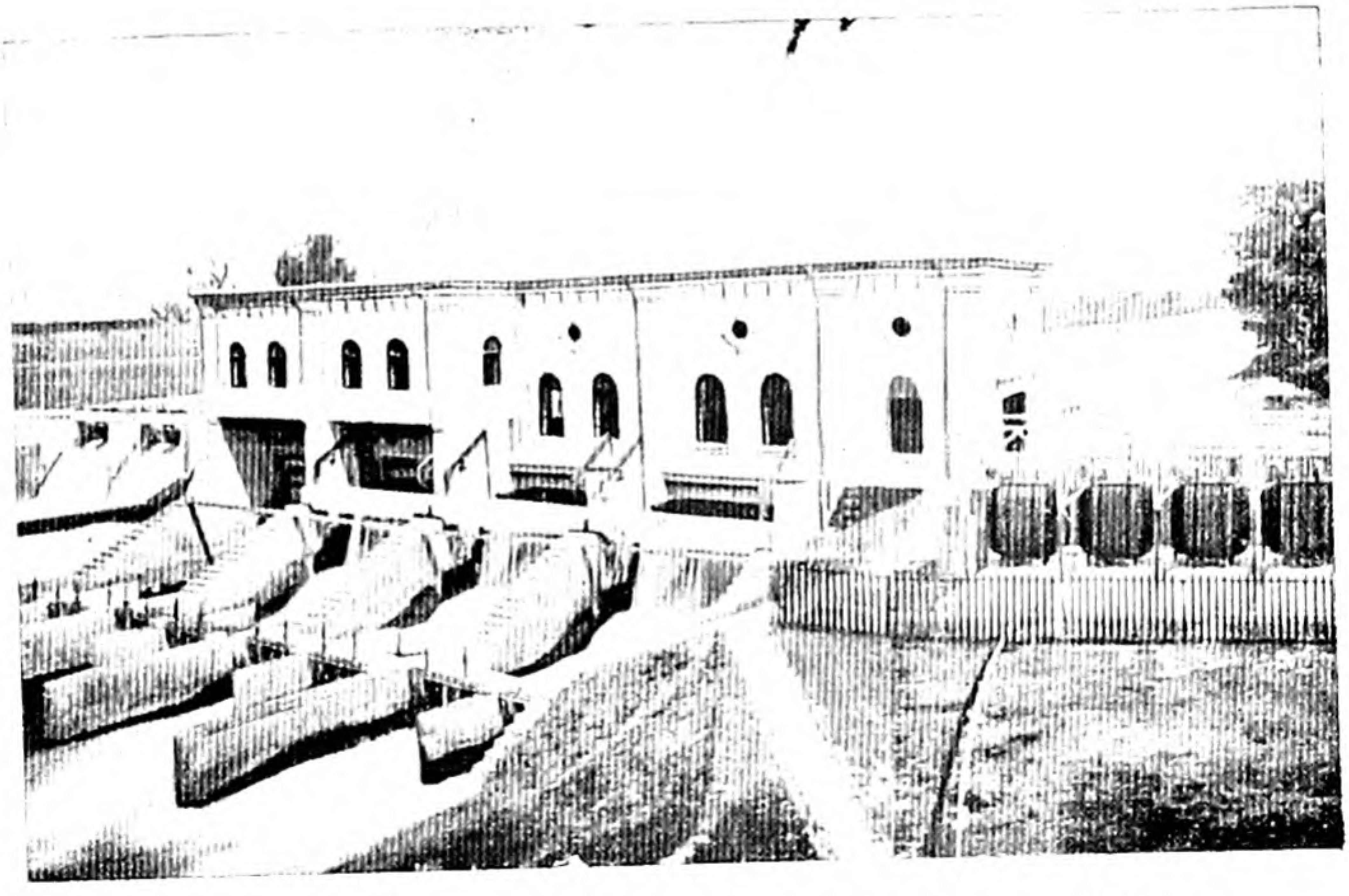


Fig. 2—Bahadurabad Power Station, viewed from downstream side.

drop and will replace the existing Bahadurabad Power Station which, as noted above, has an installed capacity of 4,400 K. W. and which utilises only a fraction of water power available in the Upper Ganges Canal. This scheme will effect an increase of 15,100 K. W. on the Ganges Canal hydroelectric grid and will provide great relief to the heavily overloaded grid. The scheme has been sanctioned by the U. P. Government.

It is ultimately expected that 24,000 K. W. will be developed from water and about 30,000 K. W. from coal. The power generated at different falls has been connected into a grid known as the Western Grid with 2,000 substations, which covers a network of high tension lines exceeding 2,000 miles in length through the 14 western districts of the United Provinces, and as far as Shahdara in Delhi Province. In this area cheap power is available for domestic, agricultural and industrial purposes for 100 towns, many of them having a population of less than 10,000 people.

The total cost of this grid is 3½ crores of rupees and one-third is approximately the cost of the generating stations.

The connected load of 35,000 K. W. is distributed as follows :—

Industrial purposes	... ...	12,000 K. W.
Irrigation by pumping	... ...	15,000 K. W.
Agricultural purposes	... ...	3,000 K. W.
Domestic and other purposes	... ...	5,000 K. W.

It will be observed that nearly half the power is used for irrigation purposes and about one-third for industrial requirements. Thus it has been made possible to provide cheap water power for pumping water from rivers, open and tube wells which have provided irrigation to 1,000,000 acres of land which were hitherto without any source of irrigation.

It may be noted that this scheme was developed in a series of stages : thus the initial outlay was not heavy. The power stations are located near the centres of utilisation and thus great initial expenditure on lengthy transmission lines was not necessary. Cheap electricity has been provided to large agricultural regions and an important tube well irrigation scheme, as noted above, has been brought into operation. The Western Grid system is alleged to be an excellent example of economic development both for hydroelectric power and irrigation.

The United Provinces, according to Meares have minimum resources of continuous water power of 400,000 K. W. and possibly a maximum of one million K. W. The present total exploited energy is below 20,000 K. W. representing 5 per cent. of the minimum continuous power and 2 per cent. of the maximum potential resources. This will reveal the possibilities of future power development in these provinces.

It may also be noted that the thermal power generated in the United Provinces is 102,000 K. W., exceeding five times the power generated by water. Important centres, where thermal power is generated, are Kanpur (Cawnpore), Chandausi and Moradnagar.

Potential Resources and New Projects

It has been referred to above that great potential resources of water power remain unexploited in the United Provinces. The rivers, debouching from the Himalayan gorges on to the plains, in a series of cascades, possess great potential resources of power. There are several projects under investigation and consideration of the Government. The most important of them comprise :—

1. Sarda Power Station.
2. The Nayar Dam (Marora) Project.
3. Pinder Project.
4. The Rihand or the Son Valley Project.
5. The Ramganga Project.
6. Kothri Dam Project.
7. The Yamuna Project.
8. The Betwa Project.
9. The Gogra Project.

1. Sarda Power Station

In this project it is intended to combine a large number of existing falls on the Sarda Canal into a single drop and a power station is being constructed by the Government of the United Provinces on this Canal at Khatima, 9 miles from its headworks at Banbasa. An escape, 12½ miles in length, is being dug up in which a pit, 60 feet in depth, will be fitted up with generating plants. It will generate 41,400 K. W. including seasonal power. The project, which is expected to be completed by 1951, will cost about Rs. 2.89

crores, while the transmission lines will cost another Rs. 4 crores. As many as 8,000 workmen are employed at the site and the work is being pushed on with all possible zeal. It will supply electric power for domestic, agricultural and industrial purposes to the districts of Naini Tal, Almora, Bareilly, Pilibhit, Shahjahanpur, Lakhimpur Kheri, Sitapur, Hardoi, Lucknow, Bara Banki, Unnao and Rae Bareli.

2. Nayar Dam (Marora) Project

It is a multipurpose scheme intended to provide irrigation and generate hydroelectric power. No doubt, the project will be of great benefit to the agricultural and industrial development of the picturesque region. A dam, 600 feet high, approximately thrice the height of the Mettur dam, so far the highest built in India, is to be constructed across the Nayar, a tributary of the Ganges (Ganga). It will be located near Marora village in the district of Garhwal, some 50 miles north of Hardwar. When completed it will approximate in size and height to the Boulder Dam in U. S. A., one of the highest in the world. It may be noted that unlike the chief Himalayan rivers, the Nayar is not snow-fed. It is intended to impound the monsoonal flow of the river and release it through the sluices on to the Ganges. It is noteworthy that this water will sustain the flow of the Upper Ganges Canal at its maximum, i. e., 8,500 cusecs during the months of December and January.

The installed capacity of water power will be 200,000 K. W. at Marora and 32,000 K. W. at Byasghat. It will provide irrigation to 238,000 acres and

will improve irrigation of another 1,068,000 acres at present served by the Upper Ganges Canal System. The cost of the project is expected to be Rs. 24 crores and it will take 8 years to be completed.

The Nayar Valley is not rich in minerals, but ores of iron and copper, lignite, asbestos, soapstone, gypsum and graphite are known to occur in Garhwal. With the help of cheap water power, lumbering, fruit canning, cement and woollen textile industries may develop, thus converting backward Garhwal into a part of Switzerland. This project will help to produce 232,000 maunds of additional food grains, 150,000 maunds of sugar and 60,000 maunds of cotton.

This dam will enjoy a strategic position between the Yamuna (Jumna) and the Sarda. A hydel scheme, described above, is under construction on the Sarda Canal, while work on the Yamuna scheme, described below, has also commenced.

As noted already, the Upper Ganges Canal Grid supplies power to 14 districts of the Western United Provinces, but with the completion of the Marora Project, 24 districts of the province will be electrified. The artificial lake will be a great blessing to anglers, yachtsmen and holiday makers.

3. Pinder Project

This scheme envisages the construction of two dams 200 feet and 500 feet in height near Karanparyag across the Pinder river, a tributary of the Ganges. It will generate 40,000 K. W. of firm power and 50,000

K. W. of seasonal power. Preliminary investigations of the project have already been undertaken.

4. Rihand Dam Project

This project will harness the waters of the Rihand, a tributary of the river Son. The dam, 280 feet in height will be built across the Rihand at Pipri village in the Mirzapur district, about 34 miles south of Chopan on the Son. The site of the dam, which the author visited in the beginning of 1947, is located in granite which has intruded into the phyllites. The catchment basin, which partly lies in the Rewa-State, has an area of 5,000 square miles, and the flood discharge has been estimated at 500,000 cusecs. The reservoir, which will occupy an area of 180 square miles, will have a capacity of 9 million cubic feet. It will generate 230,000 K. W. with production cost of a pie per unit. The cost of the main dam will be Rs. 16.25 crores, while the cost of a subsidiary dam at Obra will be another 3 crores and the transmission lines will cost an additional Rs. 10 crores, thus making the total estimated cost of 29 crores.

The Rewa State has decided to take full advantage of the project by starting the manufacture of cement, textile, paper, glass, sugar, aluminium, plywood, matches and fertilizers. The scheme will also involve flood control, provide irrigation facilities to 4 million acres and help to develop important fisheries in the reservoir. It will take 6 years to complete the project from the date of commencement.

5. Ramganga Project

This is another big project. The dam is to be constructed 340 feet above the river bed across a gorge in the Kalagarh forest area, two miles above the Kalagarh Forest Rest House in the Garhwal district. It will provide irrigation to some 800,000 acres and generate 66,000 K. W. of electric power when the project is completed. The project is expected to cost Rs. 14 crores.

6. Kothri Dam Project

A dam, 250 feet in height, is proposed to be constructed across the Kothri river, a tributary of the Khoh, which will impound 180,000 acre-feet of water. The scheme will generate 5,000 K. W. of secondary power and about two-thirds of the water will be used for irrigation in the Garhwal district and the adjoining Bhabhar areas.

7. Yamuna (Jumna) Hydroelectric Project

Actual construction has commenced on this scheme and cheap power will be available by the end of 1953 when Stage I of this project will be completed. In this stage a barrage, 2,048 feet in length, will be constructed across the river Yamuna,* two miles downstream of its junction with the river Tons in the Dehra Dun district. This barrage will divert the supplies

* It was written as the Jumna before, but the U.P. Government have now revised the spellings.

of the river into a concrete-lined power channel, 8 miles in length and having a full supply capacity of 4,600 cusecs. There will be two drops of 50 feet and 100 feet in the power channel where power stations having an initial installed capacity of 17,000 K. W. and 34,000 K. W. respectively will be constructed. Later a spare generating set of 8,500 K. W. will be installed in each power station.

The construction of stage II of the project will be commenced just before the completion of Stage I and is expected to be finished in five years. It will comprise a 70-foot high dam in a narrow gorge of the river Tons near Kishau village. A 7 miles long and 20 feet in diameter concrete-lined tunnel in two sections is to be driven in the intervening hills forming a double loop in the river Tons. A power station utilising a drop of about 600 feet and with an installed capacity of 1,60,000 K. W. will be constructed at the end of the tunnel, about half a mile upstream of the barrage of stage I. Thus the total drop used for power generation in the rivers Yamuna and Tons will be 750 feet. The entire project, including the cost of transmission lines, is expected to cost Rs. 21 crores. Stage I will develop 40,000 K.W. during the whole year for industrial and domestic consumption. Besides seasonal power from the middle of May to the end of October to the extent of 47,200 K. W. from Stage I and 72,800 K. W. from Stage II will also be available at comparatively cheaper rates. The project will be of course of great assistance in the industrial advancement of the province. It is expected to yield a net annual income of Rs. 16.6 lakhs.

8. Betwa River Project

The Betwa, a tributary of the Yamuna (Jumna), is a seasonal torrential river with an annual discharge of 300,000 cubic feet of water which calculates to 10,000 cusecs per day. It rises in Bhopal at an elevation of 1,500 feet above sea level and in the United Provinces the river drops from 1,300 to 850 feet in a course of 150 miles. It flows through rocky country with a steep gradient having numerous rapids and many suitable sites for storage reservoirs. The river is suitable for the development of multipurpose schemes and possesses great potential power and irrigation resources.

When fully harnessed the Betwa can provide storage for 250,000 m. cft. and can generate upto 300,000 K.W. in several stages. Irrigation requiring a storage of 70,000 m. cft. could be provided to 1½ million acres of agricultural land. Thus the Betwa can help in supplementing 200,000 tons of food by intensive agriculture.

Cheap power can be produced almost as a by-product in a region nearest to the nerve centres of the United Provinces, which will be sufficient to meet the domestic, industrial and other loads of some 15 big towns of Bundelkhand.

First Stage of the Project

With the construction of Piprai Dam, Dhukwan Dam can be regulated to pass a minimum discharge of 555 cusecs rising to 830 cusecs at certain times during 9 months of October-June. During the monsoons the river carries not less than 10,000 cusecs daily. The

available drop at Dhukwan varies from 32 to 51 feet at different times of the year.

The first stage of power development provides for the installation of two sets of generators of 5,000 K. W. each at Dhukwan. The production of power during the non-monsoon months will vary from 1,600 to 2,300 K. W., while during the monsoon months it will be 10,000 K.W. Thus coupled with the existing thermal stations in Jhansi firm power produced will be 2,500 K.W. during dry season, while it will be 10,000 K.W. during the monsoon when it will not be necessary to operate steam stations.

With the development of the First Stage about 1,600 K.W. will be supplied to Jhansi, Lalitpur, Hamirpur, Orai, and Kalpi. The surplus power will be injected into Kanpur[1] (Cawnpore) at a uniform rate of 3 pies per unit.

The total outlay of the scheme is Rs. 1,31,00,000 including the laying of transmission lines and purchase value of the thermal station in Jhansi. The expected return is 8.3 per cent.

This project will no doubt help to develop the agriculture and industries of Bundelkhand which is the most backward tract in the United Provinces. It will help in effecting the saving of coal particularly during the monsoon period at the thermal stations of Kanpur (Cawnpore) and Jhansi.

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1. It was written as Cawnpore before, but now the U. P. Government have revised its spellings.

Second Stage

The second stage comprises the construction of Singhpura Dam, 99 feet in height, on the Betwa, five miles below the existing Dhukwan Dam for irrigation purposes for the development of the Betwa Canal Command, providing a discharge varying from 1,160 to 1,500 cusecs during October to June.

There are two steep rapids in the Betwa near Orchha, 11 miles from Jhansi. They represent sites for two separate power houses, two miles from each other. There will be thus two falls each of 95 feet, the first being at Singhpura, as mentioned above and the second at Orchha, where a dam 40 feet in height is proposed to be constructed above the fall. The flow of the Lalitpur, Piprai, Dhukwan and Singhpura has been closely corroborated with the requirements of the Betwa Canal. The power available at Singhpura and Orchha is 7,800 K. W. and 8,900 K. W. respectively. Two half units, each of 11,500 K. W., have been proposed to be installed both at Singhpura and Orchha power houses. During the monsoon they will be working to their full capacity to provide power for seasonal industrial loads at Kanpur (Cawnpore), Allahabad and Agra. The total firm generated-power is 14,500 K. W., while seasonal power during the monsoon is 45,000 K. W. It is proposed to connect Agra via Gwalior, to Kanpur and to Allahabad via Banda and Karvi. It is assumed that the power will be injected into the Grid at Agra at 4 pies per unit.

The total cost of the scheme is estimated at Rs. 4.7

crores and the expected annual return is 5.8 per cent. It will take 3 years to complete the project. The cost of generating power calculates to 1.35 pies per unit.

The further development of this project comprises other four stages, but these are mere suggestions placed on record at present for consideration at some future date.

9. Gogra Power Project

This scheme, which will benefit both the United Provinces and Nepal, is intended to harness the potential resources of the Gogra river for the development of power. It is proposed to short-circuit the loops in the Karnali river by boring tunnels across the intervening hills, which will provide a drop of about 1,000 feet for the development of power. In two stages 300,000 K.W. of power will be generated.

CHAPTER XVIII

BIHAR AND WEST BENGAL

Damodar Valley Project

The proposed scheme for the development of the Damodar Valley provides for a satisfactory control of floods, sufficient water for irrigation and generating hydroelectric power, a system of navigation, water supply, etc. Other related aims are malaria control, silt control and the question of sand supply for sand stowing in the coalfields. The magnitude of the project could be gauged by the fact that it involves a total expenditure of Rs. 55 crores and a consideration of geographical, agricultural, industrial and social conditions in a river basin having a population of 5 million people with another $2\frac{1}{2}$ millions in the adjoining areas. It may be noted that the population is mainly agricultural, but the occurrence of coal deposits and the additional development of hydroelectric power offer industrial possibilities. The project comprises a series of storage reservoirs for purposes mentioned above.

Flood Control :—The Damodar is notorious for its floods which in the past have caused a great loss of life, breach of important communications and destruction of property. Storms have also been known to occur in the vicinity of the valley. It is noteworthy that if steps are not taken now, the menace of floods may become more serious in future.

Storage Reservoirs :—The scheme proposes a system of 8 dams on the Damodar and its tributaries, seven of

them being for storage purposes, while all of them will have hydroelectric generating plants. All the dams would be in Bihar and the entire scheme would cover a catchment and drainage basin of over 9,000 square miles.

Every endeavour will be made to avoid submersion of coalfields and the coal industry would be supplied with all information about dams and the related reservoirs.

Irrigation :– At present the Damodar and Eden Canals provide partial irrigation to 186,000 acres on account of the restricted flow during the dry weather. The new scheme would offer perennial irrigation to 760,000 acres including the present 186,000 acres, partially irrigated. This irrigation will be provided to a region where the prospects of food production are grave.

In West Bengal alone it well help to increase production of rice by 5 million maunds *per annum*.

Power :– The scheme provides for the generation of considerable amount of hydroelectric power. The present installations, which are all thermal, are inefficient and obsolete and mean on an average high cost of production. Total power developed will be 65,000 continuous kilowatts of primary hydroelectric power with an additional amount of intermittent or seasonal power up to another 65,000 kilowatts. There is a necessity for combining the hydroelectric plants, which would contain about 200,000 K.W. of generating capacity, with some 150,000 K. W. of thermal generating capacity in large modern units. The system would be

able to meet a maximum demand approaching 300,000 K. W. providing for about 1,420 million K. W. hours *per annum*. About one-half of this amount would, on the average, be provided by hydroelectric energy, the remaining being provided by thermal plants. A possibility of inter-connection in future with the proposed hydroelectric development in the Son Vally is also envisaged. The project would provide a substantial amount of power to a region capable of great industrialisation.

Navigation :–The possibility of having a navigable channel throughout the year with a substantial minimum flow appears to be a feasible proposition and will be examined further.

The scheme, apart from water for domestic purposes, would also provide an ample supply for industrial requirements.

The entire project is expected to be completed within a period of 10 years. The unified project is expected to be economically successful and in addition will provide a number of indirect benefits to the region. Thus, no doubt, the scheme, as outlined in the foregoing, will have important economic and beneficial sociological influences on the region.

It is also proposed to set up chemical and electro-chemical industries in the Damodar Valley. The former comprise the establishment of a dye-stuffs and pharmaceutical factory. The establishment of electro-chemical industries such as caustic soda, calcium carbide and the manufacture of high tension insulators is also under consideration.

It is proposed to set up a Damodar Valley Authority based on the model of the Tennessee Valley Authority with the help from Central Government as well as from the Provincial Governments of West Bengal and Bihar as the Damodar traverses the two provinces.

The functions of the Corporation will be to provide and operate schemes for irrigation and water supply for agriculture, industrial, domestic and other purposes. It will also work schemes for the transmission and distribution of both hydroelectric and thermal power. It will undertake the flood control of the Damodar river and facilitate navigation on it. Thus it will assist in the improvement of the Port of Calcutta and in the flow conditions in the Hooghly. It will promote afforestation, control of soil erosion and proper use of land in tbe Damodar basin and adjoining areas and encourage their progress in public health, agriculture, industry and general economy.

Bengal would be benefited mostly by flood control. The cost of preventive measures amounting to Rs. 14 crores would, therefore, be shared by the Goverments of India and West Bengal. Irrigation costing 13 crores and power costing 28 crores would benefit both Bengal and Bihar and the cost thereof would be shared by all the three Governments.

Mor Project

This is also a multipurpose project which provides for the construction of a dam at Messenjore and a barrage with a canal from either bank of the river Moorakshy near Suri, the headquarter town of Birbhum

district. The reservoir will have a capacity of nearly one million acre-feet. The canals will provide irrigation facilities to about 600,000 acres. There will be also a small hydroelectric generating station and the estimated cost of the project exceeds Rs. 7 crores. The additional crops, which will be grown with the help of this project, will be worth Rs. $4\frac{1}{2}$ crores *per annum*.

Jaldhaka Project

This scheme proposes to harness the waters of the Jaldhaka river in the Darjeeling District for generating hydroelectric energy. Firm power of 10,000 K. W. will be produced throughout the year, which can be increased from 17,000 K.W. to 33,000 K.W. during the monsoon. It will be able to cope with the load of tea factories in the region.

BIHAR AND NEPAL

The Kosi Dam Project

This project furnishes an excellent example of a multi-purpose project for irrigation, power, navigation, flood, silt, malaria control, soil conservation, drainage, reclamation of waterlogged areas, development of fisheries and facilities for recreation and sport. All this is discussed below.

The Kosi river, where it debouches from the mountains, is after the Indus and the Brahmaputra the third biggest of the Himalayan rivers. It is formed by the union of three streams, the Sun Kosi from the west having a catchment basin of 7,424 square miles, the Arun from the north with a catchment area of over

14,000 square miles and the Tamur from the east with a catchment of 2,278 square miles. The Kosi is noted for its vagaries and during the last two centuries has changed its course in a westerly direction to the extent of about 75 miles.[1] As a result of this drifting, agricultural land, between 2,000 and 3,000 square miles in area, has been laid waste. An important scheme has been prepared to harness the waters of this river to control floods and the drifting of the river by building a storage dam in the Chhatra gorge just above the famous temple of Barahakshetra with one or two barrages in the plain area. This scheme will thus store excess flood water with the damaging sands, which will be discharged in a regular flow for purposes of perennial irrigation to more than three million acres comprising one million acres in Nepal, two million acres in Bihar, perennial navigation from the dam site to the Ganges and ultimately to the sea, and development of hydroelectricity of about 1·8 million kilowatts at 50 per cent. load factor, thus making the Kosi power station one of the biggest in the world. This power could be transmitted for 200-300 miles and could be linked with the neighbouring projects of the Tista, Damodar, Mahanadi and Son rivers. It would thus form an important grid affecting large areas in Nepal, Bihar, Bengal, Orissa, the United Provinces, and the adjoining Indian States.

Two barrages, proposed to be built in the plain area, will not only help to train the river, but also

1. Chhibber, H. L., Westerly Drift of Rivers of Northern India and Pakistan, *Bull., No.* 12, *National Geog. Soc. Ind.*, 1949, pp. 3-16.

in the construction of irrigation canals in Bihar and Nepal. One barrage will be built across the Kosi in Nepal and a canal will be taken on each bank to irrigate about a million acres in Nepal. The second barrage will be built near the Nepal-Bihar border. Two canals will be taken from the left and one from the right bank to irrigate over 2 million acres in Bihar. The scheme will also help in the development of extensive fisheries, in the reclamation of land laid waste by the vagrant behaviour of the river and in the improvement of drainage. No doubt, the scheme will certainly help to raise standard of living of the people whose density in the flood plain is 900 to a square mile. It is also noteworthy that the flood plain of the Kosi suffers both from excess and scarcity of water. The occurrence of floods and waterlogging has been noted already; while famines have also visited the area on account of scarcity of water. The solution of the problem lies in proper land use, contour terracing and in the afforestation and conservation of soil in the catchment areas in Nepal. The precarious nature of the region as a result of deficient or erratic rainfall resulting in acute scarcity or famine emphasises the necessity for providing irrigation to save crops from failure and to increase yields, extension of agriculture and raising of double crops.

It is proposed to construct a high dam, about 750 feet high, 20 feet higher than the Boulder Dam, at present the highest dam in the world. The area thus submerged will cover about 79 square miles storing about 11 million acre-feet of water. As noted already,

the harmful sands will be trapped, while a major portion of the fertilizing silt will be permitted to reach the fields to increase their fertility.

With intensive agriculture, as a result of increased irrigation facilities, the use of fertilizers will have to be encouraged and their cheap manufacture will be rendered possible by water power generated at the dam.

With regard to the amount of expenditure it has been roughly estimated that the construction of the dam is likely to cost 15 to 20 crores of rupees and the barrages and canal systems another 20 to 25 crores of rupees. The cost of generation and transmission of one million K. W. or probably more may exceed 50 crores, but this will be carried out in stages and will be spread over many years. The total cost of the project is expected to be Rs. 90 crores.

With regard to the revenue aspect of the project it may be stated that it will have both protective and productive aspects. The former will include flood control, checking of further devastation of arable land due to the drifting of the Kosi river and reclamation of nearly 3,000 square miles of land in Nepal and Bihar already lost, together with the improvement of drainage, elimination of malaria and the reclamation of large waterlogged areas. The productive aspect of the project will comprise irrigation, and the generation of water power, the extent of which has been noted in the foregoing besides the development of navigation and fisheries.

The construction of the dam, barrages, canals and

the initial stages of power development may take about 10 years, while the raising of the dam alone may extend over five to six years.

In conclusion it may be noted that there is some hitch as the dam site lies in a seismic zone of great intensity. However, Mr. Savage, the American expert on the selection of such dam sites, has approved of the site as such dams have been constructed in the U.S.A. in similar seismic areas.

Assam

Assam undoubtedly possesses abundant potential resources of hydroelectric power in the Himalayas in the north, in the Garo and Khasi hills in the middle and in the hill ranges in the east. It has been estimated approximately that upto 4 million K. W. of continuous energy could be developed by generating power on different rivers. In the Shillong plateau near Cherrapunji alone there are a number of falls, with drops varying from 100 feet, 170 feet, 200 feet to 850 feet. All these falls occur within about 3 miles to the west of Cherrapunji. The region enjoys the heaviest rainfall in the world which could be stored in reservoirs for which ideal sites are available in the deep gorges in the plateau. In fact, Assam is one of the best endowed provinces in India so far the development of hydroelectric energy is concerned. It could easily provide cheap water power to its multitudinous tea factories. Likewise irrigation could improve the silk industry and the agricultural production of the province. Most of these projects could be developed on a multi-purpose basis for generation of power, perennial irrigation, extension of navigation, flood control, etc.

If these schemes are developed no doubt they will change the whole economic position of the province.

ORISSA

MAHANADI PROJECTS

Hirakud Dam

The province of Orissa with its newly merged states has an area of 51,000 square miles and a population of 12 millions. It is traversed by three rivers, the Mahanadi, the Brahmini and the Baitarni. With all its mineral, forest and agricultural resources it is still the most backward province in India.

Great agricultural and industrial improvements are envisaged in Orissa after the construction of the Hirakud Dam. The report by Central Waterways Irrigation and Navigation Commission to the Government of India compares Orissa of today to Ukraine in U. S. S. R. before the construction of the Dneiper Dam. The province will benefit tremendously by the multipurpose scheme and it will develop into a region of utmost importance with its considerably increased food resources, industrial development of its rich mineral resources and its command of strategically important waterways.

The Mahanadi has been notorious for its floods, but if its waters are fully harnesssed, they will not only afford complete protection from floods to the delta area, but would provide irrigation to an extent of over 20 million acres of land or in fact to every available

acre of land. The power generated will be of the order of 4 million K. W. which is twice the amount developed at the 26 dams of the Tennessee Valley Authority. The scheme would also provide navigation with a minimum draught of 9-10 feet extending over a distance of 380 miles from the border of the Central Provinces to the sea. A deep seaport could also be developed for Orissa at Chandbali or Dhamra capable of handling 6 million tons of traffic. It may be noted that the seaport of Calcutta during pre-War years handled nearly 10 million tons of traffic. It will create extension lakes which could serve as sea-plane bases and help to develop important fresh-water fisheries.

The complete project of development of the Mahanadi valley will consist of three units :–

(a) the Hirakud Dam Project.
(b) the Tikarpara Dam Project.
(c) the Naraj Dam Project.

Each unit will have its own canals and hydroelectric power installations. They are capable of independent development and also of forming an integrated part of the development of the whole basin.

The Hirakud project lies uppermost on the Mahanadi river and is the simplest in respect of physical features and other considerations. It comprises the construction of a dam, 3 miles in length across the Mahanadi, about 9 miles above the town of Sambalpur with gravity and lift canals and two hydroelectric

installations. The reservoir will submerge an area of 135,000 acres and will have a storage capacity of 5.3 million acre-feet.

Hydroelecticity will be generated at two power houses, one of which will be located at the main dam at Hirakud and the second at the subsidiary dam forming the balancing reservior at the end of the power channel from the upper power house. It will utilise the steep slope in the river below Hirakud. The operating head at each power house will be 85 feet. The total installed capacity at the two power houses will be 350,000 K. W. There will be six units of 25,000 K. W. each installed at the upper power house and eight units of 25,000 K. W. each installed at the lower power house. The units will be installed in stages to suit the development of load. It is proposed to connect these power stations to Cuttack and Jamshedpur and later on to Machkund Power Station. It will provide irrigation to more than one million acres of land.

With cheap power available to the extent, noted above, an industrial town will be established near Sambalpur and factories for the manufacture of cement, iron, steel, aluminium, paper, textiles, sugar, cotton, fertilizers, chemicals, etc. could be installed. Raw materials including coal, iron, limestone, bauxite, timber, grasses, etc. are available within convenient distances. This will effect considerable saving in transmission cost and losses.

The project will also render the Mahanadi a navigable

waterway. The total cost of the project is estimated at Rs. 47.81 crores comprising as follows :—

Flood control	...	...	6. 11	crores
Irrigation	...	...	11. 12	,,
Power	...	...	29. 58	,,
Navigation	...	...	1. 00	,,

It is expected to bring an annual return of 4. 29 per cent. on the capital outlay. The Prime Minister of India, Pandit Jawaharlal Nehru performed the foundation concrete laying ceremony in April, 1948 and the project is expected to be completed in six years. It will be responsible for effecting an increase of 340,000 tons in the food resources of the Sambalpur District and Sonepur State. It will also augment a great deal the production of the delta region.

Machkund Project

The Governments of Madras and Orissa have launched a joint project to harness the waters of the Machkund river at Duduma falls for generating hydroelectric power. It will be developed in four stages with an ultimate development of 100,000 K. W. In the first stage power upto 34,500 K. W. will be generated by 1950. The second stage comprises the construction of the Jalapat Dam. In the third and fourth stages further penstocks and generating sets will be provided. The estimated cost of the project is Rs. 6 crores rising to Rs. 8.4 crores in 10 years. The work has already commenced.

RAJASTHAN

Jawai River Project

This project is a multipurpose project both for irrigation and development of hydroelectric power. The reservoir with a capacity of 0.17 million acre-feet on the Jawai is one mile east of Erinpura Road Railway Station on the Bombay Baroda and Central India Railway. It will irrigate an area of 110,000 acres. There will be a hydroelectric station of 1,570 K.W. at the canal head, while at the canal tail, where there is a drop of about 92 feet, there will be another station with a maximum output of 2,530 K.W. The estimated cost of the project is 1.67 crores of rupees. The construction began in early 1946 and water for irrigation purposes was expeeted to be available by the end of 1948.

Chambal Valley Project

This project proposes to harness the waters of the Chambal, which flows through Rajputana and Central India, for irrigation and development of cheap water power. A concise account of the course of the Chambal has already been given on pp. 48-49 of Part I of this work. The multipurpose regional development of the Chambal Valley comprises a number of schemes. The first of a series of reserviors envisages the construction of a dam, about 200 feet in height and 1,000 feet in length, across the Chambal near Chaursiagarh in Holkar State, about 30 miles north-west of the Shri Chhatrapur Railway Station on the B. B. & C. I. Ry. The storage capacity of the reservoir, having an area of 250 square

miles, will be 6.89 million acre-feet. It will generate 28,000 K.W. of continuous power and provide irrigation to about 100,000 acres. The project is estimated to cost Rs. 7 crores.

In addition, there will be two pick-up weirs, one in Mewar and the other in Kotah State. The power stations at these weirs will produce 68,000 K.W. and 56,000 K.W. respectively at 50 per cent. load factor. They will irrigate another 200,000 acres. The estimated cost of the entire project will be Rs. 22.5 crores. It is estimated that the cost of generating electricity will be less than three pies her unit and will be supplied to consumers at eight pies per unit.

Rural electrification and the development of cottage industries will be encouraged and power will be utilised for pumping water for agricultural purposes. It will make an annual saving of large quantities of coal and considerable rail transport.

The region is rich in minerals like, copper, lead, zinc, mica, clay and there is a large scope for the establishment of cement, glass, pottery and other industries. Near Sambhar there is an excellent scope for chemical industry and there are other raw materials available for the development of other industies. In brief these barren waste lands will be converted into a fertile and industrial region.

Central Provinces

In this province most of the rivers do not have continuous supply of water at all seasons, yet the Narbada, Tapti, Indrawati, Kanhan. Penganga and

Wainganga can generate sufficient continuous power. The minimum continuous power, which can be generated, is given below:-

(1) The Narbada, 50 miles south of Jubbulpore, 10,000 K.W.

(2) The Tapti near Burhanpur, 90,000 K.W.

(3) The Indrawati in Bastar State, 60,000 K.W.

(4) The Kanhan near Nagpur, 13,000 K.W.

(5) The Penganga in Yeotmal, 11,000 K.W.

It has been suggested that the investigation of these schemes should be expedited as much as possible as the development of power is an essential prerequisite for industrial development. It may be added that one of the first steps of the Russian "First Five Year Plan" comprised the scheme for supply of electical energy to as large an area as possible.

Narbada Project

A colossal multipurpose project to harness the waters of the Narbada for developing water power, irrigation, navigation, pisciculture is under consideration. The dam is proposed to be constructed near the village of Bargi, about 25 miles from Jubbalpore and a reservoir more than 100 square miles in area will benefit a tract occupying several hundred square miles and will augment wheat production. The project is estimated to cost more than 100 crores.

Wainganga Project

This is another large project which will benefit the province immensely. When completed it will generate

1.1 million K.W. of cheap water power for industrial and agricultural advancement. It will irrigate nearly a million acres of land and will effect 320 miles of navigation. The scheme will help to control the Wainganga and thus eliminate its floods and soil erosion. It will also provide an outlet for navigation from the hinterland to the Bay of Bengal. The reservoir will submerge 640,000 acres of which only 248,000 acres will comprise agricultural land.

The project is estimated to cost about 50 crores of rupees. In the meantime the Government of India have advised the Central Provinces Government to proceed with their thermal schemes in order that electricity may be availabale at an early date for industrial devlopment. This advice has been accepted by the C. P. Government.

Bombay

The Presidency of Bombay enjoys a heavy rainfall and the position of the Western Ghats is particularly favourable for the development of hydroelectric power. The Ghats attain an elevation of more than 2,000 feet within a few miles of the city of Bombay.

Khopoli Hydroelectric Works:--The hydraulic works of Tata Hydroelectric Power Supply Co. near Lonavala are situated at the top of the Bhor Ghat. A lake known as the Lonavala monsoon lake has been formed by damming the headwaters of the Indravani river near the edge of the Ghat. The waters of the lake are adequate to meet the requirements for generating power during the monsoon, but the water,

required during the dry season of 8-9 months, has to be supplied by storage. For this purpose two storage lakes have been formed. The first has been created by raising a masonry dam across the mouth of a valley, near the Walvhan village, while the second lake has been formed by a masonry dam built across the Shirawta valley. The two lakes have a combined storage capacity of 10,000 million cubic feet. From these three lakes, water is carried to the Power House at Khopoli lying at the foot of the Ghats, with a normal capacity of 48,000 K. W. It provides a head of 1,726 feet. Power is transmitted to Bombay at a distance of 43 miles.

Andhra Valley Project:—Another suitable site for the development of hydroelectric power was found on th Andhra river to the north of the above lakes, where another 48,000 K.W. could be generated. The Andhra Valley Power Supply Company came into being and a dam, 190 feet high, was raised across the Andhra river. A tunnel, 8,700 feet in length, was constructed through the Deccan Trap to the scarp of the Ghats. The water was then carried in steel pipes over a length of 4,000 feet to the Power House at Bhivpuri, thus providing a head of 1,740 feet. The power is then carried to Bombay over a distance of 56 miles.

Nila Mula River Project:—Another project on the Nila Mula river, south-east of Bombay was developed by the Tata Power Company. It comprises a storage reservoir formed on the Nila Mula river west of Poona and south of the above two projects. The storage capacity of the lake, which is situated on the east side of the Western Ghats, is 16,500

million cubic feet and a tunnel, about 3 miles in length, has been driven through the Ghats to take the water to the generating station at Bhira having a normal capacity of 87,500 K. W. and the power is taken to Bombay by a line 76 miles in length to augment the supply from the previous two schemes.

The total normal capacity of these three concerns by Tatas, which operate as a single unit, is 183,000 K. W. The total amount expended on these schemes is 16 crores of rupees and these schemes have been economically very successful bringing an annual dividend of 8 per cent. and even more. The power is is supplied to various large companies in Bombay including the Bombay and Poona Electric Supply Companies, the Tramway Company of Bombay and the B.B. and C.I. Railway and G.I.P. Railway for their city and suburban and the latter's main line to Poona and Igatpuri. Bombay is the second city in India, but represents the largest manufacturing centre The textile mills and other industrial concerns use about 150,000 H.P., thus causing a great saving in the consumption of coal which had to be transported over great distances.

New Projects

The following multipurpose schemes are under investigation and consideration of the Government :–

Koyna Project

This scheme comprises the building of a dam, about 300 feet in height acros the Koyna river, a few miles north of Helwak. The reservoir thus created will have a storage capacity of about 2.5 million acre-feet for

the development of power to an extent of 250,000 K. W., while part of the water will be used for irrigation purposes. When the project is completed, it will be one of the bigger power stations in India.

Kalinadi Project

This project proposes to harness the waters of the Kali river for generating 300,000 K. W. of continuous power in five power stations. The districts of Dharwar, Kanara, Belgaum and Bijapur will be benefited by this scheme.

BARODA

Zankhari Project

It is a small project, which envisages a masonry dam, 3,500 feet in length across the combined Zankhari and Gira valleys and the reservoir will have a storage capacity of 120,000 acre-feet. It will provide irrigation to an area of 9,000 acres and the falls on the canal will generate 2,300 K. W. of power. The estimated cost of the scheme is one crore of rupees.

Sabarmati Project

It is proposd to build a masonry dam across the Sabarmati river, which will make a reservoir with a storage capacity of 230,000 acre-feet. A pick-up weir will be constructed 25 miles downstream. It will provide irrigation to 45,000 acres and will generate 6,000 K. W. of power. The estimated cost of the project is Rs. 2 crores.

Madras

It is remarkable that the Presidency of Madras had two small hydroelectric schemes since the beginning

of the present century, the first at Munnar which was installed by Kannan Devan Hills Produce Co. in 1900 and the second at Karteri established by Aravankad Cordite Factory in 1902. A third scheme was brought into operation at Annalley by Anglo-American Tea Company in 1915. But the real advance in the electrification of the Presidency was made with the Pykara scheme.

Pykara Scheme

In this scheme the waters of the Pykara river, draining the Nilgiri hills and having a catchment of nearly 38 square miles, are utilised. A fall of about 3,100 feet has been harnessed, but the discharge, although perennial, is very variable, being 20,000 cusecs in July and 15 in the month of May. However, there are several storage sites, which could be utilised according as the demand increases. The installed capacity is 44,400 K. W., while the potential capacity is 69,000 K. W. The Glenmorgan reservoir, representing the first site, has a storage capacity of 26 million cubic feet in the forebay. However, rapid demand for power led to the construction and completion of the Mukurti dam in 1938.

Coimbatore is the main receiving station: Transmission lines have been extended to Trichonopoly, Erode and Negapatam, a distance of 200 miles. However, in June, 1937 they were connected on to Mettur Dam scheme. Further supplies since 1937 have been made over a distance of 145 miles to Undumalpet, Sembatte, Madura, Virudhunagar, Koilpatti, etc.

The expenditure on the Pykara Scheme uptil 1936-37 has been Rs. 2,10,80,789. The cost of installed power at Pykara is Rs. 864 per K. W.

The third stage of the extension of the Pykara Scheme was launched to cope with the increasing demand for power in the Pykara areas and also to supply the seasonal as well as emergency deficiency of the Mettur and Papanasam projects. To effect this extension a dam will be constructed across the Pykara river to form a reservoir of 45,800 acre-feet to generate 212,000 K W. The initial estimated cost of the scheme is Rupees twe crores and Rs. 3.6 crores at the end of the tenth year.

Moyar Project

This project proposes to utilise the tail water of the Pykara Power House in the Nilgiris District over a drop of 1,200 feet in the Moyar valley, about 10 miles north-east of the present Pykara House. The power generated here is to meet the increasing demand for power in the Pykara and Mettur Systems. According to *New Projects for Irrigation and Power in India*, 1948, the installation will comprise three numbers 12,000 K. W. turbo-generator sets and the power house will be connected to Pykara by a double circuit line and to Mettur at Erode by a double circuit line, 72 miles in length.

Mettur Dam

This dam, known as the Mettur Stanley Dam on the Cauvery is 176 feet high with a storage reservoir of 93,500 million cubic feet of water and represents one of the biggest schemes of its kind in the

world. The scheme is mainly for irrigation purposes, but some of the water is also used for the development of hydroelectric power. Four cast iron pipes, 8 feet 6 inches in diameter and equipped with necessary fittings were fixed into the masonry dam. The maximum head with full reservoir level is 160 feet, while the minimum is 60 feet, the average being 135 feet. The installed capacity is 37,C00 K. W. which can be increased to 50,000 K. W. There is great variation in head and discharge and consequently the Mettur power is classified under three heads :– (a) primary power available throughout the year, (b) secondary power with restricted use in the dry season. This, however, can be converted into primary power with the help of the Pykara scheme and (c) tertiary power generally available for eight months *per annum*. This scheme supplies power to the districts of Salem, Trichnopoly, Tanjore, North and South Arcot, Chittoor and Chingleput. As noted already, this system is linked at Erode on to the Pykara system.

The cost of the Mettur Scheme is Rs. 97,49,098, while the cost of installed power at Mettur is Rs. 200 per K. W. It may be noted, however, that this does not include the cost of headworks at Mettur, which were primarily built for irrigation in the Cauvery Delta.

Papanasam Scheme

A fall of about 370 feet on the Tambrapani river in the Tinnevelly district has been harnessed for the development of power in this scheme wihch

started operating in August, 1944. Above Papanasam, in the foot-hills of the Western Ghats, a masonry dam, 179 feet in height has been raised across the Tambrapani just below its confluence with the Kariar. As at Mettur water is being led by two pipes having a diameter of 8 feet 6 inches. The total capacity is about 21,000 K. W., which can be extended to 28,000 K. W. and the transmission lines extend to Tuticorin, Koilpatti and Madura where it has been linked on to the Pykara Scheme.

There is a total length of 3,701 miles of transmission lines in the Madras Presidency.

Ramapadasagar Project

The project is to harness the waters of the Godavari near Pollavaram and a dam, 428 feet in height with the lowest foundatiou level 190 feet below the river bed and 1½ miles in length, will be constructed. It will store 15.6 million acre-feet of water and will from one of the biggest reservoirs in the world. One canal will take off from the left bank of the reservoir and two from the right bank, which will irrigate 2.35 million acres of undeveloped paddy land in the four districts of Vizagapatam, Godavari, Kistna and Guntur and will improve irrigation facilities to another 2.1 million acres of land.

Firm Hydroelectric power will also be generated to the extent of 100,000 K. W. besides 20,000 K. W. of secondary power. Below the dam it will render the Godavari navigable throughout the year.

It is par excellence the most important multipurpose project in Madras and the estimated cost is Rs. 86 crores

and will take 12 years to be completed. It will help to produce one million tons of rice *per annum* worth Rs. 24 crores at the current rates.

Tungabhadra Project

This project, which has been undertaken conjointly by the Governments of Madras and Hyderabad, comprises a concrete dam, 160 feet in height aud 8,200 feet in length, across the Tungabhadra. The course of this river, which is a tributary of the Kistna, has been described on pp. 40-41 of Part I of this work. The reservoir will impound 2.6 million acre-feet of water which will be shared equally by these two territories. Power will also be generated in Madras Presidency. The estimated cost of the project in Madras alone will be Rs. 10 crores.

The Hyderabad part of the project, which is well advanced, will generate 136,000 K.W. of power and irrigate 600,000 acres of land.

Kistna Hydroelectric Project

This project comprises the construction of two reservoirs, one on the Kistna river at Siddeswaram in the Kurnool District and the other on the Pennar at Someswaram in the Nellore District. The water from the Kistna reservoir will be diverted to the Pennar river for irrigating about three million acres through Bhavanasi river in the Kistna valley through a canal in deep cutting in the ridge between the Kistna and Pennar valleys. An important canal, 300 miles in length, will be issued from the Pennar reservoir and the estimated cost of the scheme is Rs. 78 crores.

Bhadra Reservoir Scheme

A dam, 185 feet in height above the river bed, will be constructed across the Bhadra at Lakkarally, which will impound 1.55 million acre-feet of water to irrigate 180,000 acres. The water will be used for generating power before letting it into irrigation canals. The power thus generated will be 12,660 K. W. The estimated cost of the scheme is Rs. 8.88 crores.

Mysore

Mysore State was one of the earliest to realise that progress was best achieved through the utilisation of electric power. The industrial advancement of Mysore could be easily attributed to the development of electrical energy.

Sivasamudram Project:—It is noteworthy that the hydroelectric project on the Cauvery at Sivasamudram in the Mysore State represents the first project of any magnitude com menced in India. The Cauvery bifurcates into two branches round the island of Sivasamudram and the falls are situated across the branches, one on the eastern in Madras Presidency and the other on the western in Mysore territory. The two branches unite again, about 1½ miles below the falls. A small generating plant of 4,500 K. W. was installed in 1902 with the main object to supply power to the gold mining companies at Kolar at a distance of 95 miles from the power station, but since that date the supply of power has been extended to a total installed capacity of 42,000 K. W. which supplies power not only to the cities of Banga-

PLATE XXXII.

To face page 392.

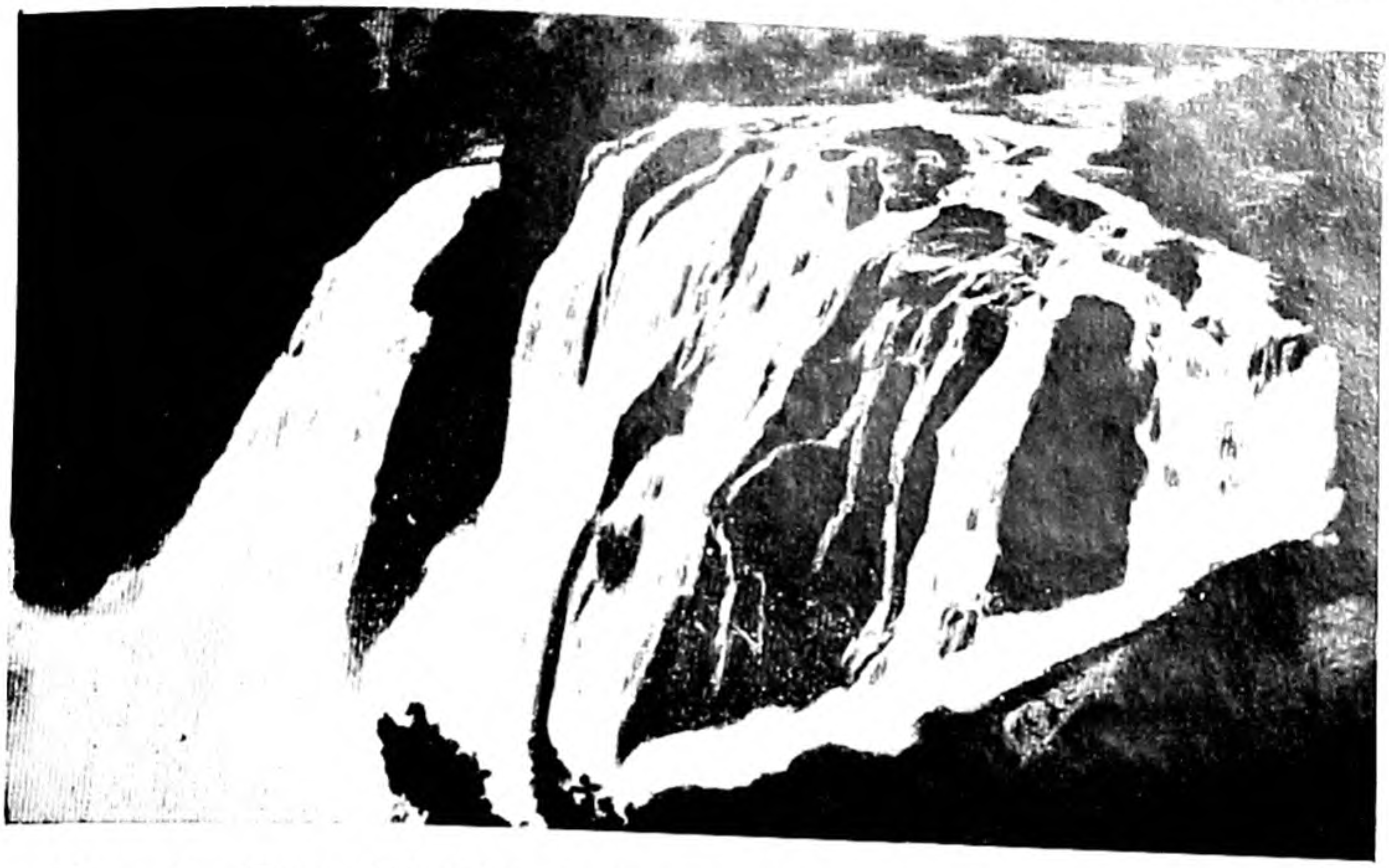

Fig. 1—Bara Chukki Falls at Sivasumadram, Cauvery.

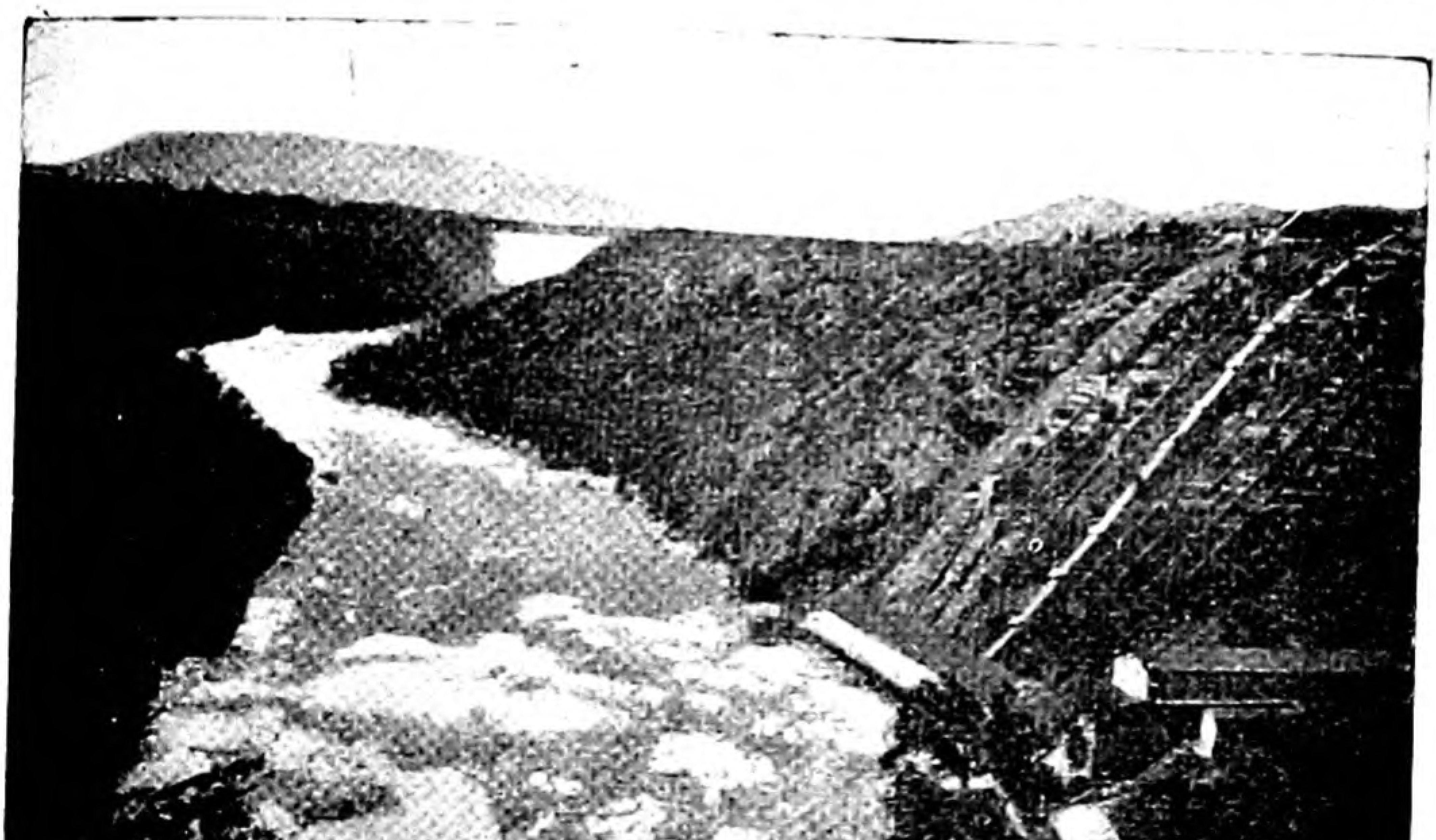

Fig. 2—River Cauvery near the Generating Station.

Borrower's No.	Issue Date	Borrower's No.	Issue Date

lore and Mysore, but also to about 200 other towns and villages.

This system has been linked to Krishanarajasagar reservoir which was completed in 1927 and with an actual capacity of 35000 K. W. although the installed capacity is 42,000 K. W.

Shimsha Falls:—In 1940, the Shimsha falls with a head of about 600 feet have been utilised for the generation of 17,200 K. W.

Mahatma Gandhi Hydroelectric Works:—Another station at the Jog Falls on the Sharavati river in the Sahyadri mountains has been just opened and will be capable of generating at least 12,000 K. W. in the first stage which could be augmented to 72,000 K. W. The river falls here in a sheer drop of 850 feet over the famous Jog or Gassapa Falls. These works have been renamed as Mahatma Gandhi Hydroelectric Works. The power from this scheme will be shared by the neighbouring provinces of Bombay and Madras.

The project has cost 6 crores of rupees. The present capacity of the generating station at Jog is 48,000 K.W., but in view of the rapidly increasing demand for power, it will be increased to its ultimate capacity of 1,20,000 K. W. and the whole scheme is expected to cost Rs. 5.7 crores.

With the completion of this project, Mysore's three beautiful falls, viz., Cauvery at Sivasumadram, Shimsha at Shimshapur and Gassapa on the Sharavati will be linked together over a total distance of 300 miles. This

grid will supply power to hundreds of large and small towns.

Travancore

A small hydroelectric power station existed in Munnar in the high ranges of Travancore as early as 1905, but systematic development of water power commenced in 1934, when the Pallivasal project was taken in hand to exploit the falls of the Mudrapuzha river. The first stage of the project was completed in 1940 and the total capacity of the generating station is 21,000 K. W., but it can be increased to 36,000 K. W. Hydroelectric energy is transmitted to Alwaye (where it is used in smelting aluminium) in the north-west and Kundara in the south.

Cochin

Hydroelectric power can be generated from four sites on the Chalakudy river within a distance of six miles. The project will be completed in five progressive stages and will then provide 200,000 K.W. at 50 per cent. load factor. In the first stage a dam will be constructed across the river above the Peringalkuthu Falls and the reservoir will have a storage capacity of 28,700 acre-feet. The completion of the project will also supply irrigation to 6,000 acres of paddy land, at present lying waste. The total estimated cost of the scheme is Rs. 20 crores.

Conclusion

The important hydroelectric projects, which have been executed in India, have been discussed above. A concise account of those, which have been launched

already or are in course of active investigation and consideration, has been also given. But it may be noted that in all provinces and important states there is a sizeable waterway, which could be harnessed to provide irrigation and develop hydroelectric power. In India there are about 170 river valley development projects large and small, under planning, investigation or execution in the country. The estimated cost of these exceeds Rs. 1,200 crores. All these cannot be undertaken simultaneously for various reasons, the most important being that building materials, machinery, technical personnel, etc., cannot be provided the same time for all of them. A conference has been convened by the Government of India to decide priorities.

The completion of these multipurpose projects is imperative as India is faced with a food deficit and huge sums, sometimes of the order of Rs. 150 crores, have to be spent *per annum* in importing foodstuffs. This is a serious drain on her finances. An earnest endeavour is being made by the Government of India to wipe out this deficit in food resources and stop imports by 1951. This is possible if all her culturable waste lands are brought under agriculture and the requisite irrigation is furnished. It is, no doubt, paradoxical to state that in recent years more land has been brought under cultivation, say, in the United Provinces, but the actual yield has decreased. This shows the necessity of using manures and fertilizers. The development of hydroelectric power, as discussed already, will lead to industrialisation which will provide varied occupa-

tion to its multitudinous population. This is essential to raise the standard of living of her populace. At present we export raw materials practically in all fields, which, no doubt, bring in low returns. But if the same materials are processed, it will not only provide more work for her people, but also considerably increased returns. Russia in her first Five Year Plan attempted to develop as much power as possible. This power will be particularly helpful in developing electro-chemical industries for which there is a considerable market inside and outside India. No doubt, full employment to the people will remove cause or causes of dissatisfaction or unrest among certain sections of the people. Industrialisation indeed appears to be the panacea of many of our ills today and it has been emphasized already that without cheap power industrial development is impossible.

It has been stated that when the projects, now under execution or awaiting development are completed India will probably rank as the third largest water power producing country in the world, being next only to U. S. A. and U. S. S. R. This will indeed bring a great change in the average standard of living in the country.

Manufacture of Hydroelectric Plant

Shri A. N. Khosla, Chairman of the Central Water Power, Irrigation and Navigation Commission, while addressing the 29th annual meeting of the Institute of Engineers (India) said that the Government of India had decided to undertake the manufacture of hydroelectric and thermal plant

in the country and the implementation of the decision might be expected within the current year. At present India is importing most of its electrical plant and equipment requirements from foreign countries. In view of the immense scope for electrical development in the country, it is most necessary that this plant and equipment should be manufactured within the country. This would lead to overall economy.

The development of these schemes would provide new avenues for the manufacture of electrical machinery and allied goods. When the various hydroelectric projects are completed, the country in order to be able to utilise this power, will need very large quantities of materials like poles, wires, transformers, insulators, switch gears, motors, heaters, accumulators, pumps, meters, etc. It is necessary that factories for the manufacture of these articles should be installed staightaway.

Utilisation of Hydroelectric Power
Rural Electrification

At present most of the existing electrical installations have been established to meet the requirements of urban centres. It may be noted that Bombay and Calcutta, which comprise a population of only one per cent. of the country, consume 50 per cent. of total electrical energy generated in India ; the remaining 50 per cent. serves the 99 per cent. of the population. As noted in the sequel, only a few villages in Madras and Mysore enjoy the benefit of electricity.

It has been noted already that cheap water power

would not only help very greatly in the industrial development of the country, but it would be a material aid in agriculture also. It would provide additional irrigation facilities from canals fed by storage reservoirs and the tail water of power stations. A large quantity of electricity would be used in lifting water from tube wells, a scheme which has been operated so successfully in the United Provinces where tube wells have provided irrigation to nearly a million acres of land, where there was no source of irrigation before. Improved agriculture and the development of subsidiary industries are bound to bring prosperity to the teeming millions in rural India. Likewise by pumping water it can help in the draining of waterlogged lands.

At present electricity is available to only 11 per cent. of the population of India and that too to the settlements of 5,000 and more, but in reality it is supplied to densely populated cities and towns. Only 0.23 per cent. of the villages with populations below 5,000 receive the benefit of electricity. This will give an idea of the magnitude of the task confronting the country. Rural electrification is a great need of the day, but it would not be a practical proposition for domestic lighting, etc. alone. Its use in pumping water for irrigation purposes, as noted above, and in the processing of its products is essential. Cheap power will help the villagers in developing semi-mechanised cottage industries like operating small flour and oil mills, mechanised spinning, weaving, hosiery machines, etc. In Mysore such an experiment has been carried out successfully.

Electrification of Railways

The electrification of railways would consume large amounts of power, and also effect considerable saving in the consumption of coal of which there are only limited resources in the country and their conservation has been emphasized already. It may be noted that the railways consume about seven million tons of coal every year which represent almost one-third of India's total consumption. On the other hand all the power required by the railways can be supplied by one large project, say that of the Kosi. It would also economise the running costs of the railways. The electrification of the following lines is already under consideration by the Railway Board.

(i) Howrah-Moghalsarai.
(ii) Bombay-Ahmedabad.
(iii) Suburban lines of Calcutta.

Decentralisation of Industries

The development of hydroelectric power will definitely help in the decentralisation of industries. This would effect a considerable saving in the transport of raw materials and the manufactured goods. This would again effect considerable saving in coal and also in the number of wagons which could be employed for other more beneficial purposes.

Development of Electro-Chemical Industries

It is noteworthy that the development of cheap power would encourage the establishment of electro-chemical industries which comprise the manufacture of inorganic fertilizers, nitrogen, potash, caustic soda,

copper, zinc, other metals and alloys, etc. Without the development of these industries, greater yields in agriculture, manufacture of machinery, armaments for national defence and the manufacture of some other vital goods are not possible.

National Grid

When all the important projects, now in course of execution, are completed, it would be possible to develop one vast national grid. In the East Punjab, the Mandi and Bhakra-Nangal schemes could be linked on to the Western Grid in the United Provinces which could be further joined on to the Sarda, Rihand and other schemes. Likewise the Damodar valley, the Kosi and the Mahanadi projects could be connected and easily linked to the various projects in South India, viz, these of Bombay, Madras, Hyderabad, Travancore, Cochin, etc. This would have the obvious advantage that in case of emergency, the essential services at least of a particular project could be operated by the neighbouring links. The thermal projects in the alternative could serve as standby plants or could augment the power generated in low water season. The location of the position of the different projects with their transmission systems on a map of India would make the feasibility of this national grid clear. A glance at Fig. 28 will also elucidate the point.

POSTSCRIPT

There is no doubt that the economic condition of the country has been deteriorating at an alarming rate. As this book deals with the basic or natural resources of the country a word about their planned development may be added. Planning Commission appointed by the Government of India is a topic of the day. There could be no two opinions about the importance of planning in the country. In fact any country which wishes to develop her natural resources in a systematic manner should proceed according to some plan. The Soviet Union since 1917 has developed her resources according to certain plans and she is now one of the most powerful countries in the world. Even Great Britain is planning the development of her resources.

The public seems sceptic whether the members of the Planning Commission are the right men capable of fulfilling the task assigned to them. Planning is the real job of a geographer. He knows what the resources of the country are and how best they can be developed. We are glad to note that the importance of a geologist is beginning to be realised in the country, but unfortunately the value of geographers has not yet been properly appreciated. Geography is generally supposed to be a subject for teaching in schools or at the most in Universities, but in other advanced countries like the U.S.A.,

U.S.S.R., etc., it is mainly the geographers who in collaboration with other scientists do considerable exploration, planning and development of the natural resources.

Reference has already been made to our notoriously low yields in agriculture and suggestions have been made in the text in appropriate places for their improvement. It has also been emphasized that the real problem is of under-production and not of overpopulation. There will be no harm done if some of these problems are recapitulated at the end. A step has been taken in the right direction in the installation of the factory for the manufacture of fertilizers at Sindri in Bihar. It is strongly hoped that this factory will commence production at an early date and the extent of its production will be such as to cope with the demand of the whole Indian Union. Land utilisation and soil surveys are practically unknown. Soil erosion, which has been dealt with in Part I of this work, is assuming alarming proportions and considerable land has been lost to agriculture as a result of ravine erosion. Our agriculture should be as much mechanised as possible. The fisheries resources of India can be increased ten times. The percentage of the area under forests is too low as compared to other advanced countries. There is an urgent need for producing more iron and steel in the country and also of large scale production of synthetic petrol, essential drugs like penicillin, etc.

It must be noted that the problem is not only of

planning, but also of the conservation and improvement of our natural resources. It is a reproach to our working and management that valuable minerals are being used as a road metal and some of the cases actually observed have been mentioned in the text.

No doubt there is also the important problem of the rehabilitation of the evacuees from Western and Eastern Pakistan. This extra man-power that has been thrown on India has to be utilised properly by rehabilitation on land, in trade and industry.

The partition has created an important problem for our cotton and jute industries. This again requires solution in order to place these industries again on sound foundations.

Of course as much irrigation as possible has to be provided for attaining self sufficiency in food resources. Likewise as much hydroelectric power as possible must be generated for our industrial development. For this a number of multipurpose projects have been under execution or consideration. Their completion has to be of course planned.

Improvement in the economic condition is dependent on the industrialisation of the country. Not only existing industry should expand, but new industrial development should be undertaken, wherever geological and geographical factors are favourable. Production must increase.

It would, therefore, appear that this planning is all imperative, but it must be made sure that the personnel of the Planning Commission is suitable.

It has been oft repeated "that the composition of the Planning Commission leaves much to be desired." There is also the controversy whether the planning should be done under socialist economy.

It has been noted in the Preface that some of the names are being revised. For instance the United Provinces of Agra and Oudh are now known as Uttar Pradesh. Likewise the Central Provinces and Central India are now styled as Madhya Pradesh and Madhya Bharat respectively. The boundaries of most of these provinces, which are now known as States remain the same, but the names of some of them have undergone modification.

Finally a word may be said about any misprints in the book. On p. xiii in the first line 1949 is of course 1947. On p. 130, in Fig. 20 the index for 8 and 9 has been interchanged.

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